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Cooperative Nutritional Status Studies in the Northeast Region

III. Dietary Methodology Studies

NORTHEAST REGIONAL PUBLICATION NO. 10

Cooperative Nutritional Status Studies in the Northeast Region

III. Contributions to Dietary Methodology Studies

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The diet record — how many and which days. *J. Am. Dietet. A.* 28: in press (1952).

Use of checked seven-day records in a dietary survey. *J. Am. Dietet. A.* 27:957–959 (1951).

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INTRODUCTION

Maynard (1) in a recent paper on evaluation of dietary survey methods points out that "the advancement of the cause of nutrition depends upon a better understanding of body needs and of how these needs can be met through an appropriate food intake. Dietary surveys serve both of these objectives in a variety of ways. They serve to chart food consumption patterns which can be studied in relation to economic and educational status, cultural backgrounds and food habits, available food supplies and other factors. They provide the basis for more effective programs of nutrition education and for the evaluation of the results. On a national or regional basis they furnish needed information for planning food production programs." Recently, much interest has been shown in various dietary study techniques to obtain information on dietary or nutrient intake to be used in the appraisal of nutritional status of either individuals or groups. The data from these studies are evaluated in terms of a standard to give indirect evidence concerning nutritional status. It is important to remember that dietary data can never measure nutritional status as such, but rather can give only indirect or presumptive evidence, which may aid in interpreting more direct nutritional findings on the individuals or groups concerned. Dietary surveys help to identify possible deficiencies in the diet and give a basis for action to improve the diet of the individual or the group. They can also contribute greatly to nutritional status studies if they are properly conducted and if the results are interpreted with full recognition of the limitations involved.

In the past five years, several excellent reviews on dietary methods employed in nutrition surveys have appeared in the literature (2, 3, 4, 5, 6). In many cases, the method of choice has been largely a matter of expediency: the one that could be carried out most effectively with the time, personnel, and money available. Expediency has applied not only to the method of collection of data, but also to the methods of analysis and of evaluation. A clear distinction has not always been made to determine whether the investigator's objective was to characterize the dietary intake of an individual or of a group. Obviously, methods suitable for the study of a population may not be suitable for the study of individuals. The choice of the method depends upon the objective to be achieved, the time and personnel available, and other circumstances. The literature contains little information based on objective research methods regarding the relative value of different dietary methods.

In 1947, funds became available under the Research and Marketing Act of 1946, for cooperative research on agricultural problems of regional character. At that time six stations of the Northeast Region instituted a study encompassing the problems of evaluating the nutritional status of population groups. The project was officially designated as R & M NE-4, Nutritional Status; the objective was stated specifically as *the correlation of dietary surveys, biochemical studies, and medical examinations* as measures of nutritional status (7). The project was primarily a study of dietary, chemical, and medical interrelationships rather than a characterization of the nutritional status of the population groups from which the samples were drawn.

One phase of the project was concerned with the assessment of the dietary intake of the individuals and groups studied. A subcommittee for the selection and standardization of the dietary procedures to be followed was organized with a representative from each of the participating stations. The selection of methods best suited to this purpose was a difficult problem. The subcommittee members felt that a valuable contribution would be made if the dietary information were collected in such a way that the various dietary study methods in common use could be compared on a group and individual basis.

The following were some of the questions in dietary methodology to which the Subcommittee felt project NE-4 might make a contribution:

1. How do the dietary history and the seven-day record compare as measures of the food intake of an individual? Of a group?

2. How does the dietary history compare with the 24-hour recall, and how does the seven-day record compare with the 24-hour recall in estimating the nutritive intake of an individual? In estimating the mean nutrient intake of a group?

3. How many and which days of the week should a dietary record include to estimate the diet intake of an individual? Of a group?

4. How many subjects should a dietary study of a population group include?

5. Would the accuracy of a seven-day record be increased if the record were checked by the nutritionist with the subject?

6. What variation is there in the weekly intake of nutrients in a selected group?

7. What variations in dietary histories may result from different interviewers obtaining the histories?

8. How do the seven-day record, an interview with the mother, and an interview with the child compare as methods of obtaining the dietary intakes of adolescent children?

9. How well are the various types of subjects under study able to estimate the type and quantity of food eaten?

10. Given seven-day diet records, recorded in measures and servings, how much effect does the interpretation of the dietary calculator have upon the estimated nutritive value of the diet?

This report represents the attempts of the Dietary Subcommittee of R & M NE-4 project to answer the preceding questions.

REVIEW OF LITERATURE

Relatively few studies pertaining to the questions considered by the present group of investigators had been made at the time the studies reported here were undertaken (1947). That the subject represents an active field of interest, among British investigators as well as American, is shown by the number of contributions that have been appearing in the literature during the past five years.

Dietary History or Inventory, Record, and Twenty-Four-Hour Recall Compared

Many types of dietary interviews are described in the literature, from brief ten-minute recalls to the detailed dietary history first developed as a research tool by Burke (8). Few comparisons have been made between the nutritive intakes of individuals or of groups obtained by the interview type of dietary study (either the 24-hour recall or the longer research type of dietary history) and the intake obtained by the various types of dietary record kept by the subject.

At the time of the present studies the literature contained only one report comparing the results of the dietary history technique with those of the dietary record. In 1942 Huenemann and Turner (9) reported a critical study of the use of dietary histories and dietary records to determine how a dietary history obtained by interview compared with an actual food record. Using 25 six- to sixteen-year-old subjects, they obtained dietary histories of the research type complete with cross-check followed by ten- to fourteen-day weighed food records. When calculations based on dietary histories were compared with those based on dietary records, it was found that no history agreed with the dietary record within 20 per cent for all constituents. Approximately one-half of the histories differed significantly from the records in five or six constituents. Dietary histories obtained by the interview method were felt to have little quantitative value, and their use as data in research programs involving small numbers of cases, the authors concluded, must be regarded as an extremely uncertain procedure. They further believed that in an individualized study the food history should be checked by a quantitative (weighed) record of food intake. The authors believed the chief reason for discrepancies was that patients actually did not know what or how much they ate.

Several attempts have been made to compare the shorter 24-hour recall with dietary records of various types. Bransby *et al.* (10) in England compared the results obtained by different methods of individual dietary survey.

The nutrient values of three-day diets of 50 ten- to fifteen-year-old boys and girls living in an institution and 28 twelve-year-old boys living at home were calculated from quantitites obtained by weighing, by recording in household measurements, and by questioning after each 24-hour period. The nutritive values were compared with values obtained by chemical analysis of duplicate diets. The questioning consisted of ten-minute interviews to obtain a recall of food intake for the last 24 hours. Weighing and measurements were made by adults; it was felt with institution children that a good test was not obtained on the questioning method because the children took much interest in the proceedings and were more aware of their food intake than usual. For the institution children, the average energy and nutritive values found by the weighing, questioning, and household measurements methods were in good agreement. Compared with the weighing method, the questioning method gave an underestimation for calories and all nutrients except fat. The boys living at home were questioned either in school without previous preparation or notification that any inquiry would be made or a comparable group were questioned after being told of the inquiry and given an opportunity to make notes of their meals. The same average nutrient intakes were found by questioning with or without memory aids; but compared with weighing, there was an overestimation of 10 per cent for calories, 12 to 13 per cent for protein, 12 to 14 per cent for carbohydrate, and 11 to 16 per cent for iron. The authors concluded that "results obtained by questionnaire are of special interest, as general impressions suggest that the method is inexact and that the resulting error must be large. The results from the National Children's Home indicate, in fact, that under certain conditions, the values may be in very close agreement with those obtained by weighing, and those from Ealing suggest that they may be close even under field conditions. Questioning has the attraction of being easy and rapid. . . ." It will be noted that this study was concerned with estimating the average intake of the group as a whole, not with predicting the nutrient intake of single individuals.

Later in the same year Eads and Meredith (11) advocated a one-day diary-type dietary record, saying it is "believed to be more accurate than a memory record." No evidence is offered for this statement. Collins (12) reports that in times of acute food shortage, such as existed in Vienna in 1946, the 24-hour dietary history (recall) technique is unreliable as a true estimate of food intake even for a group picture; yet he believes it the only method suitable for mass surveys.

Ohlson *et al.* (1950) (13) studied the dietary intake of 18 women, 48 through 77 years of age, by means of (1) three 24-hour recall interviews and (2) ten days of unrestricted weighed dietary record. The apparent mean intake of all nutrients was greater when measured by the recall diets. The authors suggest four possible explanations for the differences.

To provide more factual evidence on variations in the estimate of dietary intakes from different survey techniques, Trulson (1951) (14) obtained

dietary information from 37 clinic patients between the ages of seven and twelve by means of three techniques: seven-day record, an interview of usual food practices, and an average of three or more 24-hour recalls. Her dietary estimates were made in terms of the consumption of milk, eggs, animal protein, total protein, foods high in carotene, and foods high in ascorbic acid. The seven-day record yielded higher mean numbers for eggs and foods high in vitamin C; the interview gave highest mean values for milk; the 24-hour recall method gave the lowest mean values for all items except foods containing carotene. Trulson concludes that it is best to use only one method in conducting a study; if more than one method must be used, the investigator must remember that differences between food intakes can arise because of different methods. She states that there is no proof that one method is more reliable than another, but she prefers the interview as the method of choice for clinical studies since it may reveal long range dietary practices.

It is true that though comparisons of one method with another have been made, the comparisons have been made between methods whose accuracy and reliability are not known, so that no conclusions may be reached regarding which method is more accurate or reliable (6).

Number and Selection of Days in Dietary Record

Of the several methods for the collection of data for the study of the nutritive value of the diets of various population groups, perhaps the one most widely used for research purposes has been the dietary record, which consists of a detailed quantitative listing of all foods consumed by an individual during a given time. Whenever a dietary record has been discussed, there has been considerable doubt concerning the minimum number of days a record must be kept to yield accurate information. For example, when studying a given community, the research worker not only must be certain that the dietary record covers a sufficient period of time to furnish an adequate picture of nutrient intake, but also must avoid prolonging unduly the period of record-keeping lest the interest and cooperation of the subjects be lost. Many research workers also feel that an extended period of record-keeping decreases the subject's accuracy in reporting subsequent food intake, Eads (11). Some authorities feel that a dietary record covering seven consecutive days (3) or 20 consecutive meals (2) is the shortest length feasible from the standpoint of accuracy; however, nutrition field units operating under the direction of the U.S. Public Health Service obtain dietary information by the one-day dietary record (15). They believe that a larger number of accurately taken one-day records are as useful as a smaller number of seven-day records.

There has also been some debate regarding the necessity of obtaining data concerning nutrient intake on Saturdays, Sundays, and holidays. It is the general opinion of many research workers that eating habits of certain

population groups such as college students tend to vary considerably on Sundays and other holidays (2, 3).

The problem of how many days and which days of record-keeping are necessary was one of the earliest problems in dietary methodology to receive objective attention; yet it still continues to be debated today and remains the subject of active interest and investigation. There are two distinct problems to be investigated: (1) how many and which days are necessary to investigate the dietary or nutrient intake of an individual and (2) how many and which days are necessary to estimate the mean intake of a group. Reports have not always indicated clearly which one of these objectives the authors were seeking.

Early studies pointed to the inadequacies of short records in estimating the intake of individuals. As early as 1925, Roberts and Waite (16) found that the weighed food intake of eight children in a day nursery varied greatly from day to day in a week. They felt that the current assumption, at that time, that a two-day record gave a good estimate of the nutritive intake of a child was quite misleading. Again in 1932, Wait and Roberts (17) offered evidence of the inadequacy of a one-day dietary study to give an accurate picture of a child's customary food intake. They found that for 52 girls, ten to sixteen years of age, energy intakes on a weighed diet for one week varied from day to day, the maximum exceeding the minimum by amounts ranging from 10 to 181 per cent. They approached the problem of finding a suitable period shorter than a week by a study of all possible combinations of four consecutive days for ten subjects. Intakes for 65 per cent of the periods varied from the weekly averages by less than five per cent. In some cases, however, the variations were as much as 10 to 13 per cent from the weekly average. In a majority of the cases there was a decided difference between the average intake for the five school days and that for Saturday and Sunday. However, the averages for the five school days did not vary greatly from those for the week, the difference in all but two of the ten cases being less than four per cent. Roberts concludes that a week is to be preferred over shorter periods, but that observations over still longer periods are necessary to determine whether or not the assumption that a week is a reliable unit for study is warranted.

Koehne (1935) (18) continued work on this point and reinforced the views of Wait and Roberts. She studied the food intake of five children, recorded by weight, for 14 to 25 consecutive weeks. Intakes were calculated by the week, and then a final average made of all weekly averages for each child. Ninety-six to 100 per cent of the weekly averages for calories, protein, fat, carbohydrate, calcium, and phosphorus were within 10 per cent of the final averages. For iron, base, and acid values, 85 to 90 per cent were within 10 per cent; however, Koehne concludes that when nothing is known about previous food habits or when studies are made while the subjects are on types of diets different from those routinely eaten by them, dietary studies covering even a week or ten days rarely give results representative of a

person's customary habits. She believed studies made for less than one week would probably be wholly valueless.

Leverton and Marsh (1939) (19) approached the subject of how many and which days from still another point of view. They were interested in the possibility of using less than one-week periods for balance studies with college girls on freely chosen diets. They studied the variation in intake of nitrogen and calcium during weekdays and during the week ends (Saturday and Sunday). The percentage differences between the periods for 24 girls ranged from 2.3 to 64.3, with an average of 21.3, for nitrogen; from 0.1 to 74.9, with an average of 27.9, for calcium. The authors concluded that the results indicated a definite and significant variation in food intakes for weekdays and for week ends when college girls were living on self-chosen diets. This stresses the need of considering no less than a calendar week as the smallest time unit for studies of food consumption or metabolism. The food habits appeared to be influenced by the conventional week and week-end division of time and activities of college students.

Gray and Blackman (1947) (20) reported a study of 124 junior and senior high school boys and girls from two city and two consolidated rural schools. The one-week dietary records were analyzed by the occurrence of certain foods in the diets on school days and on week ends. They found that the week-end diets seemed poorer than those on school days, especially for rural children. City children drank more milk, and rural children ate more vegetables on school days than on other days.

Tinsley (21) studied the one-week dietary records of school children to determine how many and, particularly, which days of the week would give an estimate of the nutrient intake of the children similar to what would be obtained by a one-week record. This was done by correlating the nutritive value of the diet for various possible combinations of three consecutive days with that for the week. Some three-day periods indicated a correlation coefficient as high as 0.9, others as low as 0.75. Tinsley recommended that if a week of record-keeping is not practical and feasible on account of dwindling interest on the part of participants, three days probably represents the minimum length of time that may give a fairly satisfactory picture of the food intake of an individual. The three days suggested for school children were Sunday, Monday, and Tuesday.

McHenry *et al.* (22) in a study of food intake of a group of "normal" persons, 31 persons with scientific training, 10 of whom were directly concerned with nutritional research, found that the use of records for one week as an index of dietary adequacy gave results quite variable during 12 periods of observation (the first week of 12 consecutive months). Further examination of the data to ascertain the daily variation of intake of the various nutrients during one week indicated the inaccuracies incurred with a period of less than one week.

Having practical considerations in mind, Eads and Meredith (1948) (11) made the point that interest in diet record-keeping is maintained over a

short period and that people make a real effort to keep accurate records for one day; however, they tend to lose interest and become careless when they attempt to keep records several days. No evidence is offered to substantiate this point. Trulson (14), however, found that the initial day of a dietary record had no predictable influence. In examining 252 seven-day records kept by ten- to twelve-year-old children from two schools, she also found no evidence of consistently high or low consumption of protein, milk, or vitamin A high foods on any single day of the week. She studied the variability of intake for one-, three- and seven-day periods by means of the standard deviation; the standard deviation was reduced as the number of days studied increased up to seven, giving further stability to the means. The extent to which the standard deviation decreased by lengthening the study depended upon the food or nutrient under investigation.

Concern over the number of days necessary to characterize the dietary intake of an individual has culminated in the recent British report of Yudkin (23). He studied the diets consumed by six young women for four consecutive weeks. The diets were weighed and nutrients calculated from food tables. The weekly intake of calories and nutrients varied considerably; the extent of variation differed with different dietary components and with different subjects. Yudkin demonstrated that it was possible for a person to have an intake of any of the dietary components, which is apparently adequate in one week and inadequate in another, and he concludes that a dietary survey extending over seven days cannot be considered to give a sufficiently accurate assessment of the average intake of calories or nutrients by an individual.

Eppright *et al.* (24) reported data on the dietary intake of school children in Iowa, Kansas, and Ohio. Data from both Kansas and Iowa indicated that analysis of records for shorter periods within the week tended to be misleading in the direction of making dietary conditions seem better than they actually were. However, if a three-day period were used, any one combination of three days during the week seemed to represent the weekday intake as accurately as another, but week-end food habits were likely to differ significantly from those of the five school days. An analysis of the food consumption of a group of 50 Iowa children from city schools according to average number of servings indicated that the week-end food habits, particularly regarding milk and meat, differed from the school-day habits. In a statistical analysis of the calculated calcium, protein, and caloric intakes as obtained in seven-day dietary records of another group of 63 Iowa children comprising a random sample of a rural school, the calcium content of the diets was significantly less on the week end than during the school week. As might be expected, the intakes of vitamin A and ascorbic acid were more variable than those of other nutrients.

For the purpose of large surveys there has also been interest in finding the shortest period that can be studied to obtain an accurate estimate of the mean nutrient intake of a group. There is less objective evidence on this

point. Darby (25) reported the use of seven- or three-day records of foods eaten at each meal, the quantities consumed being estimated in household measures by the subjects, and the estimates in turn calculated to nutrients. He stated that this method is merely an approximation and is difficult to test rigidly; however, he reported that there is little reason to doubt that this procedure gives a true qualitative picture of the actual foods consumed by the population. Examination of the seasonal patterns bears this out, and attempts at quantitative expression give reproducible average results. He concluded that this method yields useful information on the mean level of intakes of a population group; it has less value for assessing the intake of an individual.

The general consensus, then, seems to be that a week is the shortest unit of time to study the dietary intake of an individual; there seems to be some evidence that a week is not sufficient. One-day studies may be useful for studying food habits of population groups (6, 11).

Sample Size

Few investigations have been made to determine the sample size necessary for various types of dietary surveys. Trulson (14) tried to determine sample sizes suitable for comparison by investigating the size necessary to give a significant percentage difference between two means. She found the greater the variability as measured by standard deviation, the larger the sample that was needed to establish differences. She concluded that the size of sample was dependent upon the nutrient under investigation.

Subject's Ability to Estimate Food Portions

If it is not possible to have weighed records of food intake, as in most dietary surveys, much of the value of the data accumulated rests upon the accuracy of the subject's ability to estimate his food intake in terms of household measurements. This ability may be affected by such factors as age, educational and intellectual levels, and motivation in cooperating in the study. Relatively few studies have been made regarding this source of variability in dietary surveys. Such a study is not an easy one to make, because (1) the study should be made under circumstances completely comparable to those existing during a survey and (2) the subject should be unaware that someone is checking his ability to estimate food portions.

In their study of school children, Eppright *et al.* (24) tried to get some estimation of the error involved in estimations of servings and household measurements in relation to the weighing technique. For 25 children for one day, the mothers recorded foods in estimated servings and household measures and then weighed the food. With calories and each of the nutrients studied, the mean nutrient intakes as calculated from estimated diets exceeded the mean as calculated from the weighed diets; but scatter diagrams

indicated that the calculated nutrients from the two types of records were correlated.

Chamberlain and Pike (26) investigated the ability of 20 eighteen- to twenty-year-old freshmen University women to estimate their food intake accurately. All food eaten by each girl had been previously weighed by someone else. Each girl kept a daily record of her intake for one week. The next day the record was checked with each subject, and quantities estimated by comparison with food models. Finally, the checked records kept by the girls and the weighed food records were calculated and compared. The average nutritional value of the diet eaten by the entire group was in close agreement when estimated by either method. The intakes of individuals varied considerably. Compared to values based on weighing, those based on the girls' estimates were +26 to −18 per cent for calories; +43 to −14 per cent, protein; +25 to −14 per cent, fat; and +30 to −21 per cent, carbohydrate. For the group, the average estimates of vitamin A, thiamine, riboflavin, and niacin by the two methods were all within 13 per cent of those derived by weighing; however, individual values varied within wide limits. Ascorbic acid estimates were consistently low.

Meredith *et al.* (27) studied the accuracy with which 94 children, most of whom were nine to twelve years of age, could report on the kind and quantity of food eaten, within one-half to two hours after the meal. The children were served a luncheon of weighed portions of food, and food left on plates was later checked for each child. Thus, the quantity consumed by each child was accurately known. The children were interviewed individually by nutritionists who had no knowledge of the menu served. Only six of 94 were able to recall accurately both the kind and quantity of all foods served. Thirty-five per cent of the children could recall all the types of food but were inaccurate in recalling the quantity for one to three items. The remaining 58 per cent of the children had inaccuracies in the number and types of food as well as quantity. It is significant, however, that a comparison of the nutritive values of weighed diets actually served to the children and of the diets recalled by the children indicated that although there was considerable lack of agreement by comparison of the items recorded by the two methods, the differences were relatively small as reflected in the calculated analysis. Ascorbic acid and vitamin A were the only nutrients in which differences appeared to be significant. Errors in recall were in slightly negative direction in omission and in quantitative errors. The fallacy of making such comparisons when the subject is aware that he is being checked is indicated by the fact that by the third day of the study in the school, better agreement between the two methods was noted, apparently because the children were conscious that they would be asked to recall food intake. More of the type of studies reported by Chamberlain and Pike and by Meredith *et al.* are greatly needed. At present on a group basis, it would appear that errors of estimation cancel out in such a way that they do not seriously interfere with obtaining reasonable estimation of the average

nutritive intake of a group. The errors, however, may be of a significant nature if one is primarily interested in nutrient intake on an individual basis.

Effect of Season

Seasonal differences in dietary intake have been reported in some studies. Because of such differences, even the food intake for a week at one time may not be taken to represent year-round food intake. There is no fixed pattern of variation. Differences are probably greater in rural than in urban areas. The degree of variation differs for various nutrients and for various food groups. Locality, food habits, and the availability of food determine to a large extent whether seasonal differences exist (6). For New York State, school children from localities of 750, 13,000, and 20,000 population, respectively, studied at two seasons of the year by Young *et al.* (1951) (28) as part of R & M NE-4 project, no significant differences were found between fall and spring intakes of the majority of the nutrients even in the more rural communities (28).

Effect of Dietary Interpretations and of Interviewers

To the best knowledge of the authors no studies have been reported, which attempt to estimate the influence of the subjective interpretations of the dietary record made by the calculator on the apparent nutritive value of the record. Eppright *et al.* tried to obtain information on the problem of interpreting size of servings. The size of servings of 60 common foods appearing on menus of nine-, ten-, and eleven-year-old children was estimated independently by the nutritionists in the three cooperating states. Close agreement existed in estimates for the majority of foods.

Similarly, though much is written on the importance of training for the dietary interviewer, no studies have been reported concerning possible influence of the interviewer upon the dietary information elicited from the subject under study.

Reports of the nutrient intake of adolescent children obtained by interviews with the mother have not been compared with those obtained by independent interviews with the children. Eppright *et al.* (24) did report such a comparison of the same daily diet record kept by the mother and by the child. There was no significant difference in the final evaluation in terms of food groups. Records kept by the mothers and sons, however, agreed more closely than records kept by the mothers and daughters. Eppright *et al.* also reported that the nutrient intake of girls was more variable than that of boys studied.

Calculated vs. Analyzed Diets

One of the most extensively investigated subjects in the field of dietary methodology has been the comparison of the nutritive value of diets deter-

mined by calculation from food tables and by actual laboratory analysis (29 to 44). A complete review of this subject is beyond the scope of the present report.

Differences in nutritive value of diets determined by calculation and by chemical analysis are due to such causes as the wide variability in the composition of common foods and, hence, the lack of accurate applicability of average values given in food composition tables, the errors incidental to the collecting and sampling of foods, and unsatisfactory methods of chemical analysis. Tables of average food composition cannot take account of all the variations in nutritive value of foods which are incidental to variety, production, processing, storing, distributing, and cooking.

From the previous literature, it would seem that there is good agreement between calculated and analyzed values for calories and protein. Results are more variable for fat content, which usually appears to be overestimated in calculating dietaries. Calculated and determined values for calcium and iron agree fairly well. In both cases, analysis is likely to give higher values. The agreement for calculated and analyzed values for vitamins is not so good. When average cooking losses are taken into account, niacin and thiamine values agree fairly well. When cooking losses are not taken into account, thiamine tends to be overestimated. Riboflavin may be underestimated by calculation. Vitamin A and ascorbic acid usually give the most divergent results; the calculated values are almost always overestimations (6). For individual diets the differences between values found by calculation and by chemical analysis may be so large that the usefulness of calculation for the study of individual diets may be questionable; however, for group averages, results are in sufficient agreement for the method of calculation to be used for survey purposes.

GENERAL METHODOLOGY

Types of Subjects Studied

It is well known to nutritionists that in collecting dietary data the methods that may be appropriate to one age, educational, or occupational group may not be to another. Hence, it was a distinct advantage to the dietary methodology studies that the various cooperating stations selected different population groups for study. The groups studied by the six stations included preadolescent and adolescent boys and girls, college students, industrial workers, and pregnant women (pre- and post-partum). Further details may be found in the bulletin, Cooperative Nutritional Status Studies in the Northeast Region: I. Techniques (7) and II. Physical Findings (45).

Collection of Dietary Data

Although cooperating states investigated different population groups, it was agreed that comparable information would be obtained by all stations

on the basis of methods for collection of data. The details of the collection of dietary information are given in the Northeastern publication previously referred to (7). In summary, the methods of collecting such information were (1) the research type of dietary history, a modification of the method by Burke (1947) and (2) the seven-day dietary record. Dietary information from individual subjects was obtained by taking the dietary history with cross-check by the interview method and then by giving instructions for the keeping of the seven-day record.

Calculation of Dietary Data

All histories and records were calculated in terms of total calories, protein, calcium, phosphorus, iron, vitamin A value, thiamine, riboflavin, niacin, and ascorbic acid. In the early studies, the U.S. Public Health Service Food Value Tables for Calculation of Diet Records (46) supplemented with values from the Bowes and Church tables (47) were used for calculation of the seven-day records. Diet histories were calculated by an adaptation of the Burke method (8), using the nutritive values of the U.S. Public Health Service tables. A simplified method of dietary calculation developed by Dr. M. J. Babcock of the New Jersey Experiment Station (48) was followed in the later studies.

Statistical Methods in Analysis

Statistical procedures in the study of dietary data have been employed to obtain objective answers to the dietary methodology questions listed in the Introduction to this bulletin. The methods for each portion of the study and the assumptions necessary in the application of the statistical tools are presented with the report of the findings of that part of the study.

Throughout the following reports the authors have tried to keep a sharp differentiation in the application or appropriateness of a given method when the objective is the study of (1) the dietary or nutrient intake of an individual or (2) the average intake of a group.

Presentation of Results

The following individual reports of each contribution of the NE-4 project to dietary methodology describe briefly the objectives of the studies, subjects studied, statistical methods, and finally the results and conclusions. Details of and justifications for the statistical procedures are listed in the Statistical Appendix at the end of the bulletin.

COMPARISON OF DIETARY HISTORY AND SEVEN-DAY DIETARY RECORD [1]

Charlotte M. Young, Faith W. Chalmers, Helen N. Church, Mary M. Clayton, Ruth E. Tucker, Anne W. Wertz, and Walter D. Foster

This report compares the dietary history and the seven-day record as measures of food intake on individual and group bases. An attempt is made to determine whether it is possible to predict the dietary intake of an individual by one method with figures collected by the other method.

Method

Subjects Studied

Table 1 lists the type, sex, and age of the subjects tested by the six stations in the present investigation. Data were collected and calculated in the manner previously described.

Statistical Treatment

The method of linear regression was followed to answer the first question (see page 10): Do the two methods give similar results in estimating the dietary intake for individuals, that is, does the history give an unbiased estimate of the seven-day record for a given individual? To answer this question, it is necessary to state specifically what is meant by bias. If the points for a nutrient were plotted on a graph where one axis represented one method and the other axis a second method, these points should set a trend

TABLE 1

Subjects Studied by the Six Stations

Type of Subject	*Male*			*Female*		
	Number	*Age in Years*		*Number*	*Age in Years*	
		Average	*Range*		*Average*	*Range*
Junior high school pupils (Me.)	30	15	13–19	33	15	13–16
Pregnant women (Mass.)				49		16–34
Industrial workers (N.J.)	129	38	20–62			
Seventh and eighth grade pupils (N.Y.)	76	14	11–18	88	13	12–16
High school and college students (R.I.)	10	18	15–26	67	19	16–27
College students (W.Va.)	17	20	17–26	51	20	18–37

[1] Portions of this paper appeared originally in the *Journal of the American Dietetic Association*, 28:124 (1952).

or should cluster about a line that would have a slope of unity if one method is an unbiased estimate of the other. If the coordinates are the same for each axis, this trend would be inclined at a 45-degree angle to each axis. Fitting a line to this trend is accomplished by computing the linear regression of one method on the other where the regression coefficient, b, is the slope of that line. Translating the question into a statistical hypothesis, we wish to learn if $1 - b = 0$. The ratio $1 - b/s.e.\ (b)$, follows Student's "t" distribution and affords a convenient test of significance. It is assumed here that these observations have a normal bivariate distribution, and although there is considerable evidence that each marginal distribution is not normal, the failure of this assumption to hold completely is believed to have little consequence on the tests here. (A further discussion of this procedure is given in Statistical Appendix A on page 86.)

The regression coefficients were examined to determine whether the relationship between the two methods of estimating dietary intake was the same for a given nutrient from station to station, with the different classes of people studied.

The second question was: Do the two methods, dietary history and seven-day record, give the same estimate of group means for each nutrient? To answer this question, two different procedures were employed. One of these was to compute the percentage difference between two means. This procedure does not answer the question of how large a difference can be tolerated except by subjective decision and entirely ignores both the variation of which the mean value is an arbitrary central figure and the number of observations in the mean. The second procedure employed Student's "t" distribution, which compares the difference between two means to the variation within each mean, utilizing the number of values represented by the mean. The paired comparison "t" test used here has the effect of eliminating variation due to individuals. Again it was necessary to assume here that these values have a normal distribution, which is often not the case. The displacement of the probability values because of the failure of this assumption to hold is not believed to be serious (49), especially in the applications presented here. Although the "t" test considers the variation in each mean, it sometimes is able to detect differences so small, e.g., two per cent, as to have little practical meaning. Conclusions were based on a joint use of these procedures.

To investigate the effect of the type of subjects studied, that is, the effect of dissimilar populations on the size of the mean difference between the two methods for a given nutrient, a study was made of the heterogeneity of these mean differences by the analysis of variance. A detailed example of the test applied here is given in Statistical Appendix B on page 86.

The correlations found between history and record were used as a criterion to answer a third question, that is, to judge whether one method could predict the value given by the second method for an individual. (See Introduction, page 10.)

Results and Discussion

Estimate for Individuals

The first question raised was whether in estimating the dietary intake of an individual, a dietary history and a seven-day record gave essentially the same answer. From a statistical standpoint, the hypothesis that history is an unbiased estimate of the seven-day record was being tested. From the data contributed by Massachusetts, New Jersey, New York, Rhode Island, and West Virginia, this hypothesis was rejected for all nutrients and for all stations, leading to the inescapable conclusion that the history did not give the same estimate of intake for an individual as the seven-day record. Similar results were found for the four-day records collected in Maine. Actual *b* values, standard errors, and correlations for this comparison are listed in Table 2.

A compound answer was found to the inquiry whether the relationship between the two methods of estimating dietary intake was the same for the different population groups studied. The relationship between the two methods was approximately the same for all the groups of people for calories, phosphorus, vitamin A, and ascorbic acid. The relationships were not the same for protein, calcium, iron, thiamine, riboflavin, and niacin.

The practical significance of this finding is best put negatively. Here is evidence that the history and the seven-day record were not always mutually consistent from population to population in estimating quantitative intake. We might infer that the degree of relative bias can vary with the type of subject when studied from the individual point of view. One might hypothesize that calories, phosphorus, vitamin A, and ascorbic acid are found in foods that are difficult for even adults to estimate, and that the other nutrients are found in foods like milk and bread, which such groups as home economics students, adult homemakers, and workers may estimate better than children. However, we should not overlook the possibility that this inconsistency could be due in part to the relative skills of the interviewers obtaining the histories, despite their training and the following of a prescribed procedure in obtaining the history.

Estimate for Group

A comparison of the dietary history and the seven-day record to describe the average intake of a group of individuals is given in Table 3. In most cases, the history considerably overestimated the intake as compared with the results of the seven-day record. The results at Rhode Island for five of the nutrients and at West Virginia for two nutrients were exceptions to this generalization. Further examination revealed that the overestimation by history was the greatest among the younger children if we assume equally skilled interviewers. The seventh and eighth grade children studied by New York gave intakes by dietary history which were, depending on the

TABLE 2

Table of Values for Regressions of Record on History[1]

		Mass.	*N.J.*	*N.Y.*	*R.I.*	*W.Va.*	*Maine*[1]
Calories, in 10's	*b*	0.43**	0.37**	0.33**	0.71**	0.53**	0.35**
	1–*b*	.57**	.63**	.67**	.29*	.47**	.65**
	s.e. (*b*)	.08	.06	.07	.12	.10	.09
	r	.63**	.53**	.35**	.60**	.53**	.45**
Protein, gm.	*b*	.38**	.29**	.41**	.81**	.48**	.42**
	1–*b*	.62**	.71**	.59**	.19**	.52**	.58**
	s.e. (*b*)	.07	.05	.07	.14	.08	.09
	r	.63**	.46**	.43**	.59**	.57**	.53**
Calcium, gm.	*b*	.43**	.36**	.53**	.57**	.84**	.59**
	1–*b*	.57**	.64**	.47**	.43**	.16 NS	.41**
	s.e. (*b*)	.07	.11	.05	.11	.11	.07
	r	.67**	.28**	.62**	.56**	.70**	.71**
Phosphorus, gm.	*b*	.42**	.32**	.46**	.70**	.57**	.44**
	1–*b*	.58**	.68**	.54**	.30**	.43**	.56**
	s.e. (*b*)	.06	.05	.10	.14	.09	.08
	r	.71**	.51**	.34**	.52**	.66**	.56**
Iron, mg.	*b*	.32**	.31**	.41**	.70**	.74**	.27**
	1–*b*	.68**	.69**	.59**	.30**	.26*	.73**
	s.e. (*b*)	.10	.06	.08	.14	.10	.10
	r	.42**	.43**	.36**	.52**	.68**	.32**
Vitamin A, 100's I.U.	*b*	.31**	.25**	.40**	.23*	.38*	.24**
	1–*b*	.69**	.75**	.60**	.77**	.62**	.76**
	s.e. (*b*)	.09	.05	.08	.11	.10	.09
	r	.44	.40	.40	.24*	.41**	.33**
Thiamine, mg.	*b*	.43**	.32**	.38**	.70**	.15*	.41**
	1–*b*	.57**	.68**	.62**	.30*	.85**	.59**
	s.e. (*b*)	.09	.06	.08	.15	.06	.10
	r	.56**	.42**	.34**	.50**	.27*	.47**
Riboflavin, mg.	*b*	.37**	.30**	.49**	.65**	.36**	.44**
	1–*b*	.63**	.70**	.51**	.35**	.64**	.56**
	s.e. (*b*)	.08	.04	.06	.11	.09	.08
	r	.58**	.52**	.54**	.59**	.43**	.57**
Niacin, mg.	*b*	.42**	.35**	.28**	.50**	.71**	.14 NS
	1–*b*	.58**	.65**	.72**	.50**	.29**	.86**
	s.e. (*b*)	.09	.06	.07	.11	.08	.09
	r	.54**	.49**	.28**	.48**	.73**	.18 NS
Ascorbic Acid, mg.	*b*	.54**	.38**	.37**	.36*	.46**	.36**
	1–*b*	.46**	.62**	.63**	.64**	.54**	.64**
	s.e. (*b*)	.14	.05	.06	.17	.10	.10
	r	0.49**	0.53**	0.41**	0.26*	0.50**	0.41**

1 Records are for seven days for all stations except Maine, which used four-day records.
* Significantly different from zero at the five per cent level.
** Significantly different from zero at the one per cent level.
NS Not significantly different from zero.

nutrient, 25 to 35 per cent higher than those recorded in the seven-day record. Junior high students at Maine reported intakes by history method which averaged 27 to 60 per cent higher, depending on the nutrient, than what they recorded in their four-day records. If records were taken as representative of the intake of the children, it would appear that children of these age groups who had not been previously schooled in the dietary history or trained to be particularly aware of their food intake should not be depended upon for reliable estimates of their intake by the history method.

TABLE 3

Percentage Differences between History and Record *

	Mass.	*N.J.*	*N.Y.*	*R.I.*	*W.Va.*	*Maine* *
Calories	9.8	12.2	24.6	−8.5	−7.2	27.6
Protein	19.8	8.0	26.8	−3.4	0.7	22.0
Calcium	27.9	28.9	31.8	11.9	8.4	29.3
Phosphorus	22.3	18.2	30.4	4.0	0.6	26.7
Iron	15.0	12.1	24.7	−7.7	−0.5	29.0
Vitamin A	32.9	46.2	35.4	28.1	27.3	60.0
Thiamine	6.7	11.4	23.6	−9.5	8.5	17.5
Riboflavin	18.3	24.7	30.3	9.1	9.9	29.6
Niacin	14.9	8.9	30.8	0.0	0.0	30.6
Ascorbic Acid	9.0	45.2	34.8	−4.5	14.5	52.0

* Records are for seven days for all stations, except Maine, which used four-day records.

On a percentage basis, Rhode Island and West Virginia, both of whom studied college students, had the best agreement of results from the history and seven-day record method. Agreement was generally within 10 per cent, vitamin A being a consistent exception. Even this exception is of considerably smaller magnitude than that for the other population groups studied. Most of the students studied were women at both colleges. Inquiry reveals that of the 67 college girls in Rhode Island, 55 were home economics students and the remaining were nursing students enrolled in home economics classes. The majority lived in dormitories. Of the West Virginia sample, 49 of 51 women were enrolled in home economics classes. The remaining two were pre-medical students, as were eight of the 17 men studied. It could be reasoned that home economics students are more food-conscious and able to give a more accurate picture. Also, the results could be a reflection of the more routine eating in a dormitory where a fairly consistent menu pattern may be followed. The underestimation of thiamine and overestimation of calcium by Rhode Island seem characteristic of the college girl who thinks she drinks more milk and eats less bread, and less calories, than she actually does.

Results from the pregnant women homemakers and male industrial workers were in an intermediate position, but the history gave consistently and substantially higher estimates than the seven-day record. From the results discussed here it would appear that the only group for whom history and

seven-day record might be expected to give similar estimates would be a group that has had experience in estimating the quantity of food eaten.

Again, the mean difference between estimates obtained by the two dietary methods for most nutrients in most states was highly significant (Table 4). In states dealing with college students, Rhode Island and West Virginia, the mean differences for approximately half of the nutrients were not significant. Thus, on the average, there was conclusive evidence that the history yielded higher estimates of mean intake than the seven-day record, although for a specific station this conclusion cannot be taken for granted. It is of interest, and not unexpected, that vitamin A proved to be the nutrient that every population group found most difficult to estimate in giving a history.

The difference between the methods for a specific nutrient from station to station was studied by analysis of variance. These differences, if they exist, would be due to the different type of subjects studied at each station or possibly differences in skill of the interviewers. The hypothesis that the differences between the two methods were the same from station to station was rejected beyond the one per cent level for all nutrients except vitamin A, where a difference would be apparent at approximately the seven per cent level. In other words, the test revealed the same results as found when percentage differences were examined: the correspondence between history and the seven-day record varied with the type of subject studied, assuming approximately equally skilled interviewers. For vitamin A, the variation between the methods was of large magnitude regardless of the type of subject studied.

Prediction from One Method

Could the intake of an individual as judged by one method be used to predict the intake that would have been obtained had the other method been followed? The answer to this question was based on a study of the correlations found between the two methods. Are the correlations sufficiently high that, given the intake by the history method, one could predict the value given by the seven-day record within a reasonable degree of accuracy?

Perhaps the best way to answer the latter question is to give an example showing the correlation required to give a predicted value within certain limits of accuracy. The data for the comparison of history and seven-day record for calcium at Massachusetts were selected for this illustration. Suppose that history indicated a mean daily intake of 1.50 grams for a subject, what correlation would be needed to predict the value for seven-day record with a deviation of less than 20 per cent in either direction? The detailed calculations for this are given in Statistical Appendix C (see page 87). For this example, the correlation necessary to obtain a prediction for the seven-day record within 20 per cent is 0.94, which is much higher than the usual correlations found in this study. Assuming that the correlations necessary

TABLE 4

TABLE OF MEANS, DIFFERENCES, AND STANDARD ERRORS OF DIFFERENCES FOR HISTORY VS. RECORD

		Mean History	*Mean Record*	*Mean Difference*	*Standard Error of Differences*	*Per Cent Difference History and Record*
Calories, in 10's	Mass.	210	192	18.76*	7.08	9.79
	N.J.	312	278	33.84**	6.45	12.17
	N.Y.	306	246	60.52**	6.09	24.63
	R.I.	197	215	18.27**	4.88	−8.50
	W.Va.	199	215	15.43**	4.52	−7.18
	Maine [1]	294	231	63.76**	9.87	27.64
Protein, gm.	Mass.	80	67	13.26**	2.43	19.84
	N.J.	100	92	7.40**	2.18	8.01
	N.Y.	101	80	21.35**	1.86	26.83
	R.I.	64	67	2.28 NS	1.51	−3.42
	W.Va.	69	68	.51 NS	2.51	.70
	Maine [1]	93	76	16.75**	3.01	21.98
Calcium, gm.	Mass.	1.21	.94	.263**	.048	27.85
	N.J.	1.18	.91	.264**	.039	28.90
	N.Y.	1.67	1.27	.404**	.029	31.84
	R.I.	.98	.88	.105**	.033	11.95
	W.Va.	1.07	.98	.083 NS	.057	8.43
	Maine [1]	1.44	1.12	.327**	.056	29.33
Phosphorus, gm.	Mass.	1.55	1.27	.282**	.050	22.31
	N.J.	1.87	1.58	.287**	.043	18.19
	N.Y.	2.06	1.58	.479**	.038	30.36
	R.I.	1.24	1.19	.048 NS	.035	4.03
	W.Va.	1.30	1.29	.007 NS	.049	.56
	Maine [1]	1.87	1.47	.394**	.066	26.71
Iron, mg.	Mass.	13.40	11.70	1.76**	.495	15.04
	N.J.	18.70	16.60	2.02**	.440	12.11
	N.Y.	15.60	12.50	3.10**	.351	24.69
	R.I.	10.30	11.10	.854**	.259	−7.67
	W.Va.	10.30	10.40	.056 NS	.302	−.54
	Maine [1]	16.	12.4	3.59**	.582	29.02
Vitamin A, in 100's I.U.	Mass.	103	77	25.49**	6.87	32.90
	N.J.	120	82	37.85**	5.33	46.22
	N.Y.	93	69	24.33**	3.34	35.39
	R.I.	70	55	15.39**	3.08	28.12
	W.Va.	77	61	16.54**	4.49	27.30
	Maine [1]	106	66	39.76**	7.16	59.98
Thiamine, mg.	Mass.	1.19	1.12	.075 NS	.039	6.71
	N.J.	1.72	1.54	.176**	.040	11.44
	N.Y.	1.69	1.37	.323**	.036	23.57
	R.I.	.98	1.08	.102**	.029	−9.48
	W.Va.	1.28	1.18	.100 NS	.076	8.50
	Maine [1]	1.60	1.36	.238**	.053	17.51

[1] Records are for seven days for all stations except Maine, which used four-day records.
* Significantly different from zero at the five per cent level.
** Significantly different from zero at the one per cent level.
NS Not significantly different from zero.

TABLE 4 (CONT.)

		Mean History	Mean Record	Mean Difference	Standard Error of Differences	Per Cent Difference / History and Record
Riboflavin, mg.	Mass.	2.20	1.86	.341**	.088	18.33
	N.J.	2.50	2.00	.495**	.068	24.70
	N.Y.	2.94	2.25	.682**	.057	30.26
	R.I.	1.77	1.62	.147**	.050	9.09
	W.Va.	1.91	1.74	.172 NS	.100	9.87
	Maine[1]	2.68	2.07	.613**	.106	29.60
Niacin, mg.	Mass.	15	13	1.92**	.53	14.95
	N.J.	21	19	1.74**	.55	8.94
	N.Y.	17	13	3.92**	.38	30.79
	R.I.	11	11	.48 NS	.32	0.00
	W.Va.	11	11	.10 NS	.37	0.00
	Maine[1]	17	13	3.98**	.79	30.62
Ascorbic Acid, mg.	Mass.	101	93	8.35 NS	4.98	8.97
	N.J.	120	82	37.23**	4.40	45.18
	N.Y.	109	81	28.24**	2.91	34.81
	R.I.	76	80	3.57 NS	3.68	−4.47
	W.Va.	76	67	9.66**	3.27	14.50
	Maine[1]	99	65	33.95**	4.78	51.96

[1] Records are for seven days for all stations except Maine, which used four-day records.
* Significantly different from zero at the five per cent level.
** Significantly different from zero at the one per cent level.
NS Not significantly different from zero.

for prediction for other nutrients would be somewhere near this figure, the prediction of intake by one method from the use of the other method to any practical degree of accuracy is virtually impossible.

Summary

1. With data from five Northeastern states representing seventh, eighth, and ninth grade pupils, high school and college students, pregnant women, and male industrial workers, a comparison was made between dietary intakes as obtained by dietary history and those obtained by seven-day records on the same subjects. In an additional state studying junior high school students, comparison was made between history and four-day record.

2. It was found almost unanimously for all population groups studied and for all 10 nutrients that the diet history did not give the same estimate of intake for an individual as the seven-day record.

3. For the mean of a group, history gave distinctly larger values than the seven-day record when applied to seventh, eighth, and ninth grade children, to pregnant women, and to male industrial workers. Differences between methods when applied to college students (primarily home economics students) living and eating in college dormitories were much smaller. However, it was impossible to ascribe what proportion of this variation was due

to age and the type of subject, to eating circumstances, and to the relative skill of the interviewer.

4. In a comparison of history and four-day record obtained from junior high students, history was found to give significantly higher estimates for all nutrients.

5. It is virtually impossible to predict the intake for an individual as estimated by a seven-day record from his dietary history with any practical degree of accuracy.

COMPARISON OF DIETARY HISTORY AND SEVEN–DAY RECORD WITH TWENTY–FOUR–HOUR RECALL [1]

Charlotte M. Young, Gladys C. Hagan, Ruth E. Tucker, and Walter D. Foster

In certain dietary studies where time and subject cooperation are at a premium, recall by the subject of his last 24-hour food intake has often been the method of expediency. What relationship exists between the dietary estimation obtained by this quick method and those obtained by the longer and much more time-consuming methods of the dietary history and the seven-day dietary record? In estimating the nutrient intake of an individual, how do results of the three methods compare? In estimating the mean nutrient intake of a group, how do the three methods compare? The present investigation was undertaken to find answers to these questions.

Method

Subjects Studied

Table 5 presents the number, age, and type of subjects studied by each station.

TABLE 5

Subjects Studied by the Three Stations

Type of Subject	*Male*			*Female*		
	Number	*Age in Years*		*Number*	*Age in Years*	
		Average	*Range*		*Average*	*Range*
Pregnant women (Mass.)				28		16–34
Seventh and eighth graders (N.Y.)	24	14	11–18	27	13	12–16
High school and college students (R.I.)	10	18	15–26	77	19	16–24

Statistical Treatment of Data

By means of linear regression, an investigation was carried on to determine whether, for the individual, the estimation of intake by the 24-hour-recall method tended to give the same results as that obtained by the dietary history and whether 24-hour recall tended to give the same estimate as the seven-day record. Regression coefficients, or the slope of the regression lines, were compared to determine whether this relationship between the 24-hour recall and the history and that between the recall and the seven-

[1] Portions of this paper appeared originally in the *Journal of the American Dietetic Association* 28 : 218 (1952.)

day record were the same from state to state, that is, for the three different population groups studied. If the same relationship existed, it would mean that the methods were relatively consistent, whether or not the methods were applied to pregnant women, college students, or grade school pupils.

The next topic that concerned the authors was the relationship between the various methods in estimating the mean intake of a group of individuals. Do the 24-hour recall and the diet history give essentially the same estimate of the mean intake of a group? What is the difference between the mean intake of the group as estimated by 24-hour recall and by seven-day record? These two questions were investigated by (1) computing for each nutrient the percentage difference between the means obtained by the two different dietary methods being compared and (2) determining by the paired comparison "t" test whether the estimation of the mean intake for a group was the same from method to method. The final answer to the comparisons depended upon the joint use of the two procedures.

Results and Discussion

Estimate for Individual

Twenty-Four-Hour Recall vs. History

For the individual, did the 24-hour recall give essentially the same estimate of nutrient intake as the dietary history? Statistically, we tested the hypothesis that the 24-hour recall is an unbiased estimate of the dietary history. The hypothesis was rejected in all cases (Table 6). The 24-hour recall does not give essentially the same estimate of dietary intake for an individual as does the dietary history.

Statistical comparison of the regression coefficient indicated that the relationship between the 24-hour recall and the dietary history was not the same for any of the three different population groups studied for all nutrients except calcium and phosphorus.

Twenty-Four-Hour Recall vs. Seven-Day Record

The same statistical procedures used to compare the 24-hour recall with dietary history were applied to compare the 24-hour recall with the seven-day record. That the hypothesis stating "24-hour recall is an unbiased estimate of the seven-day record" was rejected without exception for all ten nutrients led to the conclusion that the nutrient intakes from a seven-day record for an individual are not likely to be obtained with a 24-hour recall (Table 7). If one is interested in knowing the nutrient intake of any individual, the shorter 24-hour-recall method cannot be substituted for the seven-day-record method with any assurance of obtaining the same results.

By comparing regression coefficients, a study was carried on to determine whether the relationship is the same between the 24-hour recall and the seven-day record from station to station, that is, for grade school pupils,

TABLE 6

TABLE OF VALUES FOR REGRESSIONS OF HISTORY ON TWENTY-FOUR-HOUR RECALL

		Mass.	*N.Y.*	*R.I.*
Calories in 10's	*b*	0.88**	0.50**	0.40**
	1–*b*	.12 NS	.50**	.60**
	s.e. (*b*)	.16	.08	.07
	r	.74**	.65**	.56**
Protein, gm.	*b*	.65**	.55**	.31**
	1–*b*	.35 NS	.45**	.69**
	s.e. (*b*)	.19	.08	.06
	r	.56**	.72**	.53**
Calcium, gm.	*b*	.78**	.64**	.49**
	1–*b*	.22 NS	.36**	.51**
	s.e. (*b*)	.13	.08	.09
	r	.76**	.75**	.54**
Phosphorus, gm.	*b*	.79**	.58**	.43**
	1–*b*	.21 NS	.42**	.57**
	s.e. (*b*)	.15	.08	.08
	r	.71**	.72**	.56**
Iron, mg.	*b*	.60**	.42**	.10*
	1–*b*	.40*	.58**	.90**
	s.e. (*b*)	.17	.07	.05
	r	.57**	.67**	.25*
Vitamin A in 100's I.U.	*b*	.48**	.19*	.00 NS
	1–*b*	.52**	.81**	1.0**
	s.e. (*b*)	.13	.07	.030
	r	.58**	.36**	.01 NS
Thiamine, mg.	*b*	.31*	.44**	.26**
	1–*b*	.69**	.56**	.74**
	s.e. (*b*)	.12	.08	.06
	r	.46*	.60**	.37**
Riboflavin, mg.	*b*	.90**	.66**	.31**
	1–*b*	.10 NS	.34**	.69**
	s.e. (*b*)	.14	.07	.06
	r	.78**	.79**	.53**
Niacin, mg.	*b*	.50**	.31**	.18**
	1–*b*	.49**	.69**	.82**
	s.e. (*b*)	.15	.08	.05
	r	.55**	.49**	.30*
Ascorbic Acid, mg.	*b*	.21 NS	.36**	.16**
	1–*b*	.79**	.64**	.84*
	s.e. (*b*)	.12	.09	.06
	r	0.31 NS	0.51**	0.48**

* Significantly different from zero at the five per cent level.
** Significantly different from zero at the one per cent level
NS Not significantly different from zero.

TABLE 7

TABLE OF VALUES FOR REGRESSIONS OF SEVEN-DAY RECORD ON TWENTY-FOUR-HOUR RECALL

		Mass.	*N.Y.*	*R.I.*
Calories, in 10's	*b*	0.51**	0.51**	0.42**
	1–*b*	.49**	.49**	.58**
	s.e. (*b*)	.12	.11	.09
	r	.64**	.56**	.51**
Protein, gm.	*b*	.39*	.56**	.44**
	1–*b*	.61**	.44**	.56**
	s.e. (*b*)	.14	.11	.08
	r	.47*	.60**	.54**
Calcium, gm.	*b*	.32**	.53**	.39**
	1–*b*	.68**	.47**	.61**
	s.e. (*b*)	.10	.08	.10
	r	.51**	.68**	.43**
Phosphorus, gm.	*b*	.33*	.56**	.53**
	1–*b*	.67**	.44**	.47**
	s.e. (*b*)	.13	.09	.11
	r	.44*	.66**	.52**
Iron, mg.	*b*	.16 NS	.43**	.22**
	1–*b*	.84**	.57**	.78**
	s.e. (*b*)	.16	.09	.06
	r	.20 NS	.58**	.40**
Vitamin A, in 100's I.U.	*b*	.12 NS	.17 NS	.12**
	1–*b*	.88**	.83**	.88**
	s.e. (*b*)	.14	.09	.03
	r	.17 NS	.28 NS	.46**
Thiamine, mg.	*b*	.08 NS	.32**	.26**
	1–*b*	.92**	.68**	.74**
	s.e. (*b*)	.12	.10	.08
	r	.13 NS	.42**	.38**
Riboflavin, mg.	*b*	.37**	.51**	.24**
	1–*b*	.63**	.49**	.76**
	s.e. (*b*)	.13	.09	.07
	r	.48**	.62**	.37**
Niacin, mg.	*b*	.62**	.50**	.25**
	1–*b*	.38*	.50**	.75**
	s.e. (*b*)	.15	.12	.06
	r	.63**	.54**	.46**
Ascorbic Acid, mg.	*b*	.23NS	.26 NS	.30**
	1–*b*	.77**	.74**	.70**
	s.e. (*b*)	.11	.14	.09
	r	0.37 NS	0.26 NS	0.39**

* Significantly different from zero at the five per cent level.
** Significantly different from zero at the one per cent level.
NS Not significantly different from zero.

high or college students, or pregnant women. There was a significantly different relationship between the three population groups in only one nutrient, niacin. (A description of the statistical technique used here is given in Statistical Appendix D on page 88.) This is in contrast to the similar comparison between 24-hour recall and history. Apparently, the relationship between 24-hour recall and seven-day record for the children and women studied here was more stable than that between history and 24-hour recall. Furthermore, it seems that the variation in history caused by either the type of subject studied or the interviewers disappeared largely in the 24-hour recall.

Estimate for Group

Twenty-Four-Hour Recall vs. History

Previous findings have been concerned with the use of these methods in studying the dietary intake of individuals. A quite different problem is that of describing the dietary intake of a group of individuals. To describe a group, was the estimate of mean intake obtained by dietary histories essentially the same as that obtained by 24-hour recalls from the same subjects? The history gave decidedly higher estimates of intake than the 24-hour recall for all the nutrients at New York (grade school children) and for eight of ten nutrients at Massachusetts (pregnant women) (Table 8). For college students at Rhode Island (mainly home economics students) the reverse was true for four nutrients; though for the other six nutrients, the differences between history and 24-hour recall were negligible and not significant. Obviously, then, the magnitude of the differences between the two methods when applied to these population groups was not the same. Study by analysis of variance substantiated this conclusion for all nutrients except protein and ascorbic acid.

Twenty-Four-Hour Recall vs. Seven-Day Record

That 24-hour recall and seven-day record can be used interchangeably for the population groups studied seems to be evident. For New York (grade children) and Massachusetts (pregnant women) for all nutrients and for Rhode Island (college students) for six nutrients, there were no detectable differences between estimates for the groups obtained by the 24-hour recall and by the seven-day record, despite the fact that in a few instances the differences represented as much as 10 per cent of the seven-day mean (Table 9). It seems possible, then, that when an estimate of the mean intake of a group of approximately 50 persons or more is desired and when some errors of 10 per cent can be tolerated, the shorter, more expedient 24-hour recall can be used as a substitute for the more time-consuming seven-day record. Such a substitution would mean a tremendous saving in time, both in collection of data and in their calculation and analysis. Also, since considerably less of the participant's time and cooperation is involved, in all

TABLE 8

Table of Means, Differences and Standard Errors of Differences
History vs. Twenty-Four-Hour Recall

		Mean History	*Mean 24-Hour Recall*	*Difference of Means*	*Standard Error of Differences*	*Per Cent Difference of Means*
Calories, in 10's	Mass.	222	183	38.75**	8.53	21.14
	N.Y.	287	233	54.16**	9.11	23.25
	R.I.	196	216	20.94**	5.88	−9.67
Protein, gm.	Mass.	83	67	15.93*	3.10	23.82
	N.Y.	97	81	16.20*	2.72	20.07
	R.I.	64	69	4.98*	1.94	−7.20
Calcium, gm.	Mass.	1.24	1.03	.212**	.061	20.57
	N.Y.	1.57	1.29	.277**	.052	21.53
	R.I.	.98	.98	.001 NS	.029	.10
Phosphorus, gm.	Mass.	1.60	1.29	.307**	.060	23.84
	N.Y.	1.90	1.57	.329**	.054	20.87
	R.I.	1.23	1.28	.047 NS	.033	−3.71
Iron, mg.	Mass.	13.90	10.50	3.39**	.562	32.16
	N.Y.	14.70	12.60	2.17**	.590	17.27
	R.I.	10.20	11.50	1.26*	.510	−10.94
Vitamin A, in 100's I.U.	Mass.	103	70	33.39**	8.23	47.67
	N.Y.	88	62	26.26**	6.85	42.55
	R.I.	70	74	4.44 NS	9.36	−5.99
Thiamine, mg.	Mass.	1.25	1.19	.065 NS	.066	5.48
	N.Y.	1.60	1.43	.171**	.059	11.95
	R.I.	.97	1.12	.154**	.044	−13.65
Riboflavin, mg.	Mass.	2.33	1.84	.494**	.092	26.85
	N.Y.	2.80	2.26	.539**	.077	23.80
	R.I.	1.76	1.84	.082 NS	.075	−4.45
Niacin, mg.	Mass.	15	12	3.14**	.78	25.63
	N.Y.	16	13	3.08**	.69	23.69
	R.I.	11	12	1.04 NS	.57	−8.90
Ascorbic Acid, mg.	Mass.	101	101	.68 NS	11.49	.67
	N.Y.	87	73	13.98**	4.41	19.16
	R.I.	76	79	2.88 NS	3.90	−3.65

* Significantly different from zero at the five per cent level.
** Significantly different from zero at the one per cent level.
NS Not significantly different from zero.

TABLE 9

Table of Means, Differences and Standard Errors of Differences
Twenty-Four-Hour Recall vs. Seven-Day Record

		Mean 24-Hour Recall	*Mean 7-Day Record*	*Difference of Means*	*Standard Errors of Differences*	*Per Cent Difference of Means*
Calories, in 10's	Mass.	183	188	4.54 NS	8.33	2.42
	N.Y.	224	239	15.46 NS	8.50	6.47
	R.I.	217	215	1.88 NS	6.59	.87
Protein, gm.	Mass.	67	66	.71 NS	2.91	1.08
	N.Y.	78	79	1.48 NS	2.56	1.87
	R.I.	70	67	2.86 NS	2.06	4.28
Calcium, gm.	Mass.	1.03	.91	.12 NS	.074	13.14
	N.Y.	1.27	1.24	.031 NS	.053	2.52
	R.I.	.98	.87	.104*	.040	11.94
Phosphorus, gm.	Mass.	1.29	1.25	.039 NS	.070	3.14
	N.Y.	1.53	1.55	.021 NS	.053	1.33
	R.I.	1.28	1.19	.098*	.039	8.24
Iron, mg.	Mass.	10.5	11.4	.878 NS	.684	7.69
	N.Y.	11.9	12.1	.208 NS	.535	1.72
	R.I.	11.5	11.2	.383 NS	.495	3.43
Vitamin A, in 100's I.U.	Mass.	70	71	1.28 NS	10.87	1.79
	N.Y.	61	67	6.38 NS	7.47	9.49
	R.I.	75	55	20.67*	8.37	37.83
Thiamine, mg.	Mass.	1.19	1.11	.729 NS	.079	6.55
	N.Y.	1.36	1.30	.064 NS	.057	4.96
	R.I.	1.13	1.08	.049 NS	.046	4.53
Riboflavin, mg.	Mass.	1.84	1.82	.022 NS	.114	1.22
	N.Y.	2.21	2.24	.030 NS	.088	1.35
	R.I.	1.85	1.61	.236**	.087	14.61
Niacin, mg.	Mass.	12	13	.79 NS	.58	6.03
	N.Y.	12	13	.62 NS	.63	4.85
	R.I.	12	11	.61 NS	.51	5.44
Ascorbic Acid, mg.	Mass.	101	88	13.82 NS	10.85	15.78
	N.Y.	71	78	7.85 NS	5.42	10.00
	R.I.	79	80	.52 NS	4.50	.65

* Significantly different from zero at the 5 per cent level.
** Significantly different from zero at the 1 per cent level.
NS Not significantly different from zero.

probability a more representative sampling of the population to be studied would be possible. However, investigators are warned not to accept this conclusion unless they have, by a small pilot study, verified these results for the population and nutrients that were under consideration in their investigations. It also should be remembered that the interchangeable use of the 24-hour recall and the seven-day record applies only when one wishes to describe the mean intake of a group as a whole. As noted earlier, the two methods cannot be used interchangeably in describing the intake of individual subjects. It is of interest, further, that the size of the difference between the two methods for a group, 24-hour recall and seven-day record, was approximately the same for all three population groups studied. Throughout the groups reported here, the estimate of dietary intake obtained from the 24-hour recall seemed to be in closer agreement with the estimate obtained from the seven-day record than with that obtained by dietary history. Values obtained by history for most population groups studied were definitely higher than those obtained by any of the other estimates.

Summary

1. The dietary history was compared with the 24-hour recall, and the seven-day record with 24-hour recall, as methods of estimating the nutrient intake of an individual and of a group. Data for these comparisons were obtained from three different population groups: grade school children (New York), high school and college students (Rhode Island), and pregnant women (Massachusetts).

2. For an individual, in any of the three population groups studied, the 24-hour recall did not give the same estimate of dietary intake as the dietary history.

3. For an individual, in any of the three population groups studied, the 24-hour recall did not give the same estimate of dietary intake as the seven-day record. To describe the intake of individuals, the two methods could not be used interchangeably.

4. For the mean of a group, the dietary history gave distinctively higher values for grade school children and for pregnant women than did the estimates obtained by 24-hour recall. The history and 24-hour recall gave results which were in better agreement for the college group studied.

5. For the mean of a group, the seven-day record and the 24-hour recall tended to give approximately the same estimates for the dietary intake for most nutrients. This was true for all three population groups to which the two methods were applied: grade school, high school and college students, and pregnant women. Under certain circumstances the 24-hour recall can be substituted for the seven-day record in estimating group intakes.

THE DIETARY RECORD — HOW MANY AND WHICH DAYS[1]

Faith W. Chalmers, Mary M. Clayton, Lorraine O. Gates, Ruth E. Tucker, Anne W. Wertz, Charlotte M. Young, and Walter D. Foster

Data from dietary records collected by participating stations have been studied to obtain answers to the following questions:

1. How many days should be included in a dietary record?
   a. When the dietary intake of a group is estimated?
   b. When the dietary intake of an individual is studied?
2. Which days should be included in a dietary record?
   a. When a group is being studied?
   b. When an individual is studied?
3. How many subjects should be included in a dietary study of a population group?

Methods and Results

Table 10 lists the distribution of subjects whose seven-day dietary records were studied. In addition, 28-day dietary records obtained from 16 women and two men at the Cornell University Agricultural Experiment Station[2] and the 14-day records obtained from 13 women at the Massachusetts Agricultural Experiment Station have been examined in this study.

Number of Days

In seeking the answer for "how many days" it was necessary to estimate the correlation in dietary intake which may exist between consecutive days. Upon examination of the 28-day and 14-day diet records, in addition to the seven-day records, it was found that this correlation is virtually zero. Thus consecutive days can actually be considered as independent (Statistical Appendix E, page 88). On the basis of this finding, it was then possible to use analysis of variance and variance components in the pursuit of the original objectives.

For a Group

By variance components (Statistical Appendix F, page 89), it was found in the 150 analyses representing all nutrients and all population groups studied that only a one-day dietary record is necessary to characterize the dietary intake of a group. Since this answer held true without exception and since it is based upon data taken from a wide range of subjects, there is little reason to doubt that this conclusion may be applied to similar groups.

[1] This paper in large part appeared originally in the *Journal of the American Dietetic Association* 28: (1952).
[2] The authors are indebted to Ruth E. Franklin, formerly of the New York State College of Home Economics, for these data.

In recommending a one-day record to characterize group intake, it is interesting to note that this answer is based on the relative importance of the number of days as compared to the number of subjects. To obtain a more precise estimate of the mean intake for a group, it is more efficient to take more subjects rather than more days.

For an Individual

For an individual, a direct answer to the question of "how many days" would require extensive research. Indirectly, a generally valid answer is available from the results of the group study already discussed. The number of days to be included in the dietary record depends on the precision required, by which in general is meant the repeatability of a result. For this study, precision was measured as per cent of Recommended Dietary Allowances related to the 95 (and 99) per cent confidence interval. In estimating a mean intake, 95 per cent confidence limits are set on either side of this mean to indicate, on the average, that the true intake would fall within this interval 95 times in 100 in repeated measurements. Thus, the narrower the confidence interval is, the more precise the estimate. Figures 1 and 2 represent the average relationship of precision to the number of days in a diet record for an individual. In using these logarithmic graphs, it is first necessary to decide upon the degree of precision desired. The actual number of days required to achieve this precision in a dietary record, then, may be read directly; for example, in estimating the mean caloric intake of one male, a 95 per cent confidence interval equal to 30 per cent of the NRC standard, i.e., 15 per cent on either side, might be selected. The 30 per cent line is then located on the abscissa of the graph (Figure 1). Reading up the graph from this 30 per cent line, the number of days required would be 14. Suppose a physically active man had an estimated mean intake of 2800 calories. Then 95 per cent confidence limits based on the NRC requirement of 3000 calories would be 2800 ± 15 per cent of 3000. On the average, this man with an estimated intake of 2800 calories would have (95 times in 100) an actual intake ranging between 2350 and 3250 calories. It is evident from Figures 1 and 2 that precision tended to be greater for females than for males. Thus, to estimate a woman's caloric intake with the same degree of precision as that just described above, the dietary record needs to cover only 11 days.

As indicated in Statistical Appendix G, page 89, these graphs are applicable to all population types similar to the ones studied. The calculations for these graphs were based on the average precision for all nutrients except vitamin A and ascorbic acid. Actually, some nutrients were better estimated than others; those with the highest precision included calories and protein, whereas those of the lowest precision were riboflavin and calcium. Since these differences from the average precision did not exceed 3 per cent of the number of days needed, little error was involved by assuming that the nutrients were equally well estimated.

The vitamin A values, however, which showed extreme fluctuation, could not be used in the calculations for these graphs. Since these values were not at all comparable with the other nutrients, it is recommended that total vitamin A as calculated at the present time no longer be included in estimates of dietary intake for an individual. A further breakdown of total vitamin A values into actual vitamin A and its precursors or into animal and vegetable vitamin A might possibly reduce this variation and actually carry more meaning in characterizing dietary intake.

Dietary ascorbic acid also possessed marked variation, although to a lesser degree, and was excluded from the calculation for Figures 1 and 2. When it is particularly desirable to estimate ascorbic acid intake with the same degree of precision, it would be necessary to take 10 per cent more days than indicated on the chart. Thus, in the cases cited above, the period of record-keeping should be extended to cover 15 days for a man and 12 days for a woman.

Selection of Days

The problem of "which days" is particularly important when diet records are taken for one day. If a day effect should exist, such as a Tuesday or a Friday effect, it would become necessary to select a day representative of all seven.

For a Group

From the 150 analyses of variance, there were no significant differences beyond chance occurrence between days for any of the nutrients or for any of the population types except one. Even though the averages were not exactly the same from day to day, they still were not sufficiently different to warrant the exclusion of certain days. The one group that did not conform to this pattern was the college students studied both at Rhode Island and at West Virginia where there was a distinct decrease in food intake on week ends, which is not surprising.

Even though days were not found to be significantly different, there could exist a small but persistent tendency for certain days to show a greater intake than others. If it exists, this tendency should appear in a table of ranks, where the day of greatest intake for a group is given a rank of one and the day of lowest intake a rank of seven. Thus, when averaged over the ten nutrients, the closer the ranks cluster to a mean of 4.0, the more alike the days appear. On the other hand, the greater the spread, the stronger is the tendency to be different. The results for the groups studied are given in Table 10.

According to this reasoning, even though Junior High School I in Maine, which showed a wide spread in its ranks, might offer evidence of high intake on Sunday and low intake on Saturday, other junior high schools at Maine negated this trend. Thus, the averages of the Maine schools failed to demonstrate any consistent day effect on intake.

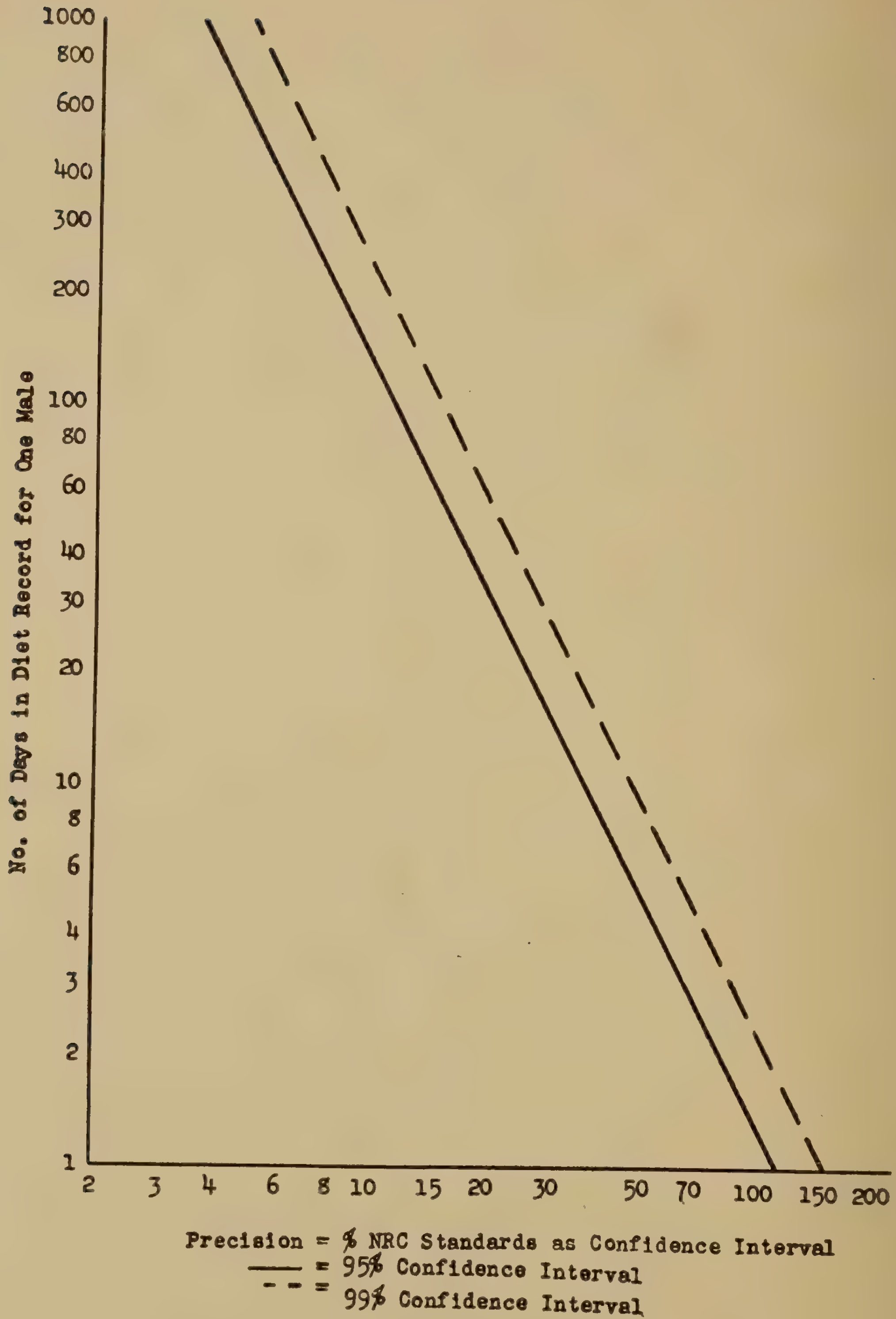

FIGURE 1

Precision vs. number of days in a dietary record for one subject (male) for calories, protein, calcium, phosphorus, iron, thiamine, riboflavin, and niacin.

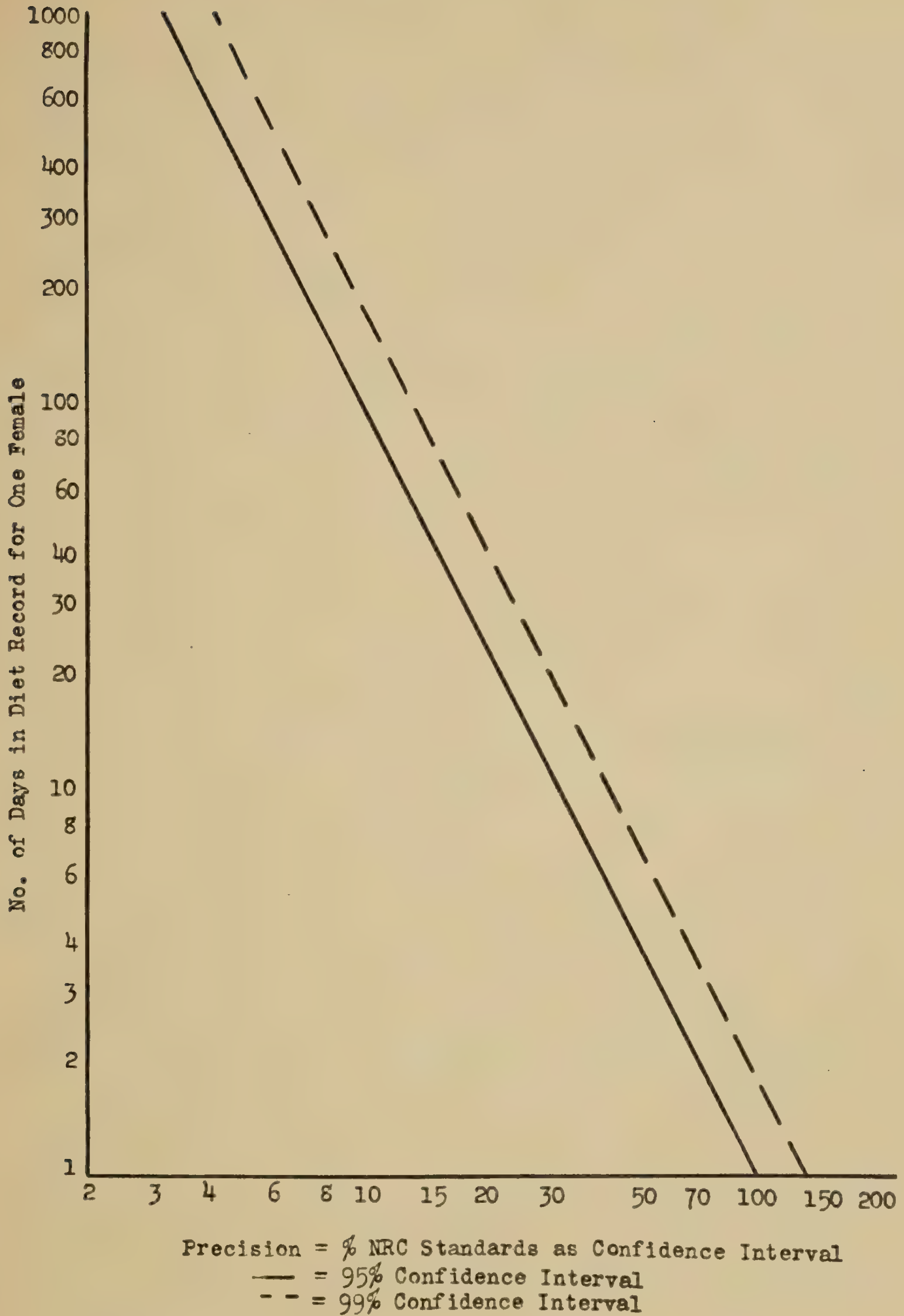

FIGURE 2

Precision vs. number of days in a dietary record for one subject (female) for calories, protein, calcium, phosphorus, iron, thiamine, riboflavin, and niacin.

Likewise for pregnant women in Massachusetts, there was some tendency for higher intake on Monday after a low intake on Sunday. The New Jersey industrial workers seemed to eat equally well on any day except Saturday.

The New York junior high school students on the average presented evidence of nearly equal intake for any day. To be sure, some of the individual grades showed a spread of ranks which might be indicative of a local trend. Greater substantiation of any local trend might be found by averaging the ranks at any one school. For example, at Junior High School II it might be inferred that the eighth and ninth graders tended to eat better on Sunday than on Saturday.

The average of the college groups at Rhode Island indicated strongly that the students ate differently over the week end compared to the rest of the week. This conclusion was substantiated in the figures from the college students at West Virginia.

TABLE 10

RANK OF DAILY INTAKE AVERAGED OVER TEN NUTRIENTS*
FOR EACH STATION AND SUB-GROUP

	Number of Subjects	*Sun.*	*Mon.*	*Tues.*	*Wed.*	*Thurs.*	*Fri.*	*Sat.*
Maine								
Junior High School I	19	1.8	3.1	3.6	5.8	4.8	2.7	6.2
Junior High School II	17	6.2	3.9	2.7	5.2	3.0	3.9	3.1
Junior High School III	21	5.0	2.8	2.5	2.9	6.5	3.1	5.2
Average	19	4.3	3.3	2.9	4.6	4.8	3.2	4.8
Massachusetts								
Pregnant Women	26	5.0	1.4	5.8	4.4	2.8	4.0	4.5
New Jersey								
Male Industrial Workers	29	3.9	3.8	4.5	4.7	4.6	4.3	2.2
New York								
Jr. High School I, 8th grade	18	2.2	4.8	2.4	5.8	3.5	4.0	5.3
Jr. High School I, 9th grade	22	4.4	3.7	4.5	6.5	1.5	4.9	2.5
Jr. High School II, 8th grade	85	2.4	4.6	2.4	5.8	3.6	4.1	5.3
Jr. High School II, 9th grade	48	2.7	4.4	3.0	2.3	4.2	5.7	5.9
Jr. High School III, 7th grade	24	4.7	5.5	1.7	3.8	5.1	2.9	4.3
Jr. High School III, 8th grade	17	3.4	3.0	4.5	4.9	3.0	3.0	5.8
Average	35.7	3.3	4.3	3.1	4.8	3.5	4.1	4.8
Rhode Island								
Sr. High School	10	3.3	3.8	4.6	3.4	5.0	5.9	2.0
College Students I	12	5.0	3.6	3.7	2.7	4.3	4.4	4.3
College Students II	16	6.9	3.7	1.1	3.9	3.5	3.1	5.8
Average College	14	6.0	3.6	2.4	3.3	3.9	3.8	5.0
West Virginia								
College Students	87	5.7	6.2	5.3	1.5	2.6	2.2	4.5

* With each nutrient, the day of greatest intake for a group is given a rank of one; the day of lowest intake, a rank of seven. When averaged over ten nutrients, the closer the ranks cluster to a mean of 4.0, the more alike the days appear. The nutrients included are calories, protein, calcium, phosphorus, iron, vitamin A, thiamine, riboflavin, niacin, and ascorbic acid.

It is apparent, then, from this table that some trends do exist, especially for certain groups. Combining the results of this table with those of the analyses of variance which showed no clearly defined day effect, we conclude that it is immaterial which day or days one selects for a record, provided no distinct tendency for a specified population has been found. That is, the absence of a day effect might be expected but should not be assumed without investigation.

For an Individual

As in the problem of "how many days" for an individual, a direct answer to "which days" also is not available. However, judging from the group findings already reported, it seems safe to assume that, for an individual, the days selected could run consecutively from any starting day as long as estimated from the graphs in Figures 1 or 2. For example, in a ten-day record started on Sunday in which Sunday, Monday, and Tuesday are repeated, the effect of omitting the remainder of the week would be negligible on the average as far as bias due to day differences is concerned.

Number of Subjects

These data also offer a basis for determining the number of subjects necessary in a group for a specified precision when measured on one day. With the same technique as previously indicated in prescribing the number of days, the number of individuals can be selected so that the estimate of the mean for the group will have a desired precision. In presenting one graph, Figure 3, approximately equal numbers of male and female subjects are assumed. Thus, to put 95 per cent confidence limits on either side of the mean of a group equal to 10 per cent of the National Research Council standard, the number of subjects required would be 60, recalling that the confidence interval here is twice the confidence limit. As before, estimation of vitamin A is not covered by this graph, and for ascorbic acid the inclusion of six additional subjects would be recommended. For a group of females, the estimate from the graph for the number of subjects required can be reduced 5 per cent for the indicated precision. Likewise, for a group of males, the estimate should be increased 5 per cent. A brief outline of the statistical technique involved is given in Statistical Appendix H, page 90.

It is possible in estimating the mean intake of a specific group that a sample of more than 25 subjects might not be available. The question then arises whether it is worth while taking more than one day. This is best answered by referring to Figure 4 in which is represented the increase in precision resulting from increasing the number of days in the diet record for two small groups. For example, in a group of ten subjects, the increase in precision resulting from taking seven days instead of one is 13 per cent, going from 45 to 32 per cent of the standard. Note that it is virtually impossible to improve the precision beyond 30 per cent in this example, no matter how many days are taken.

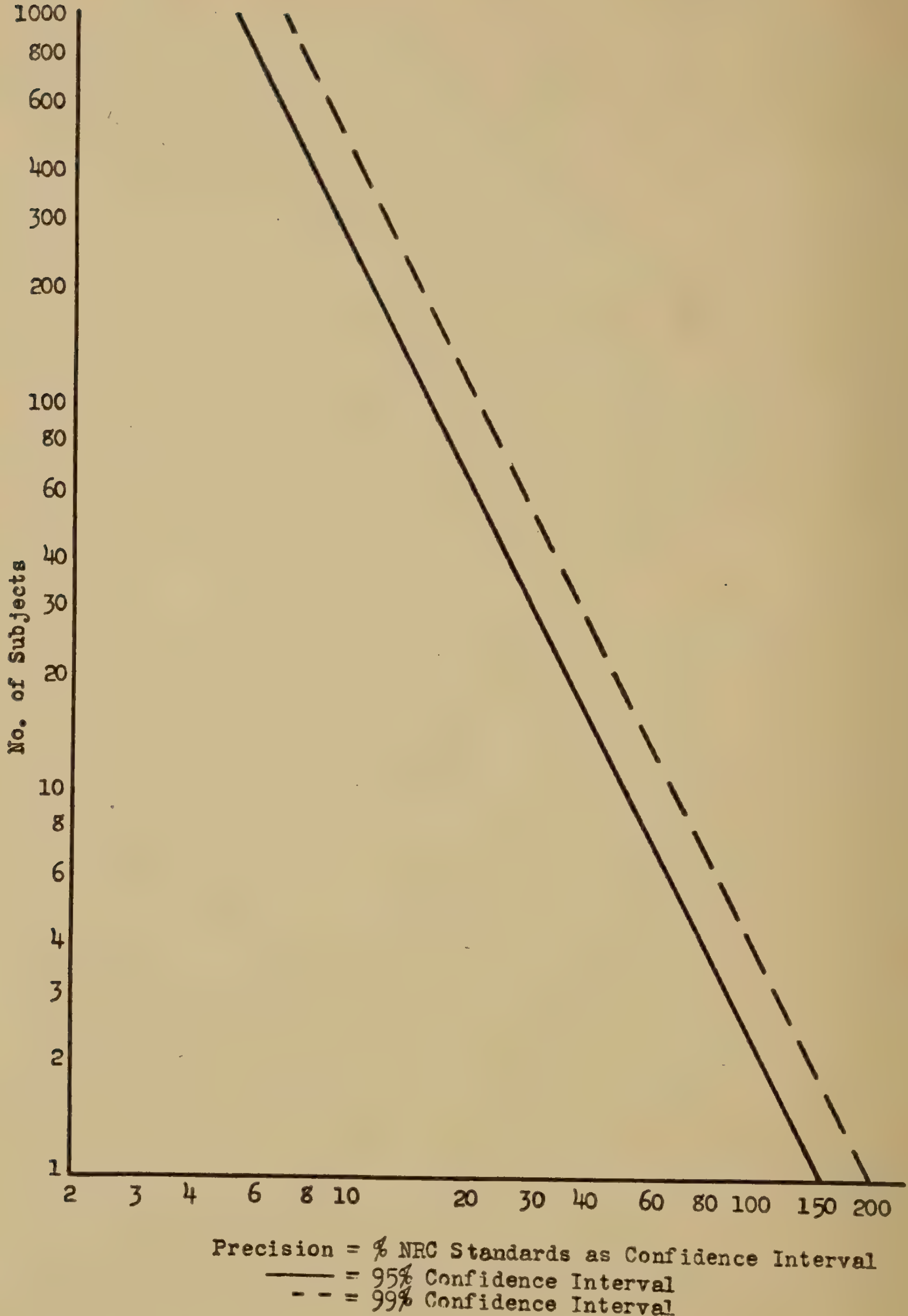

FIGURE 3

Precision vs number of subjects in a group for a one-day dietary record for calories, protein, calcium, phosphorus, iron, thiamine, riboflavin, and niacin.

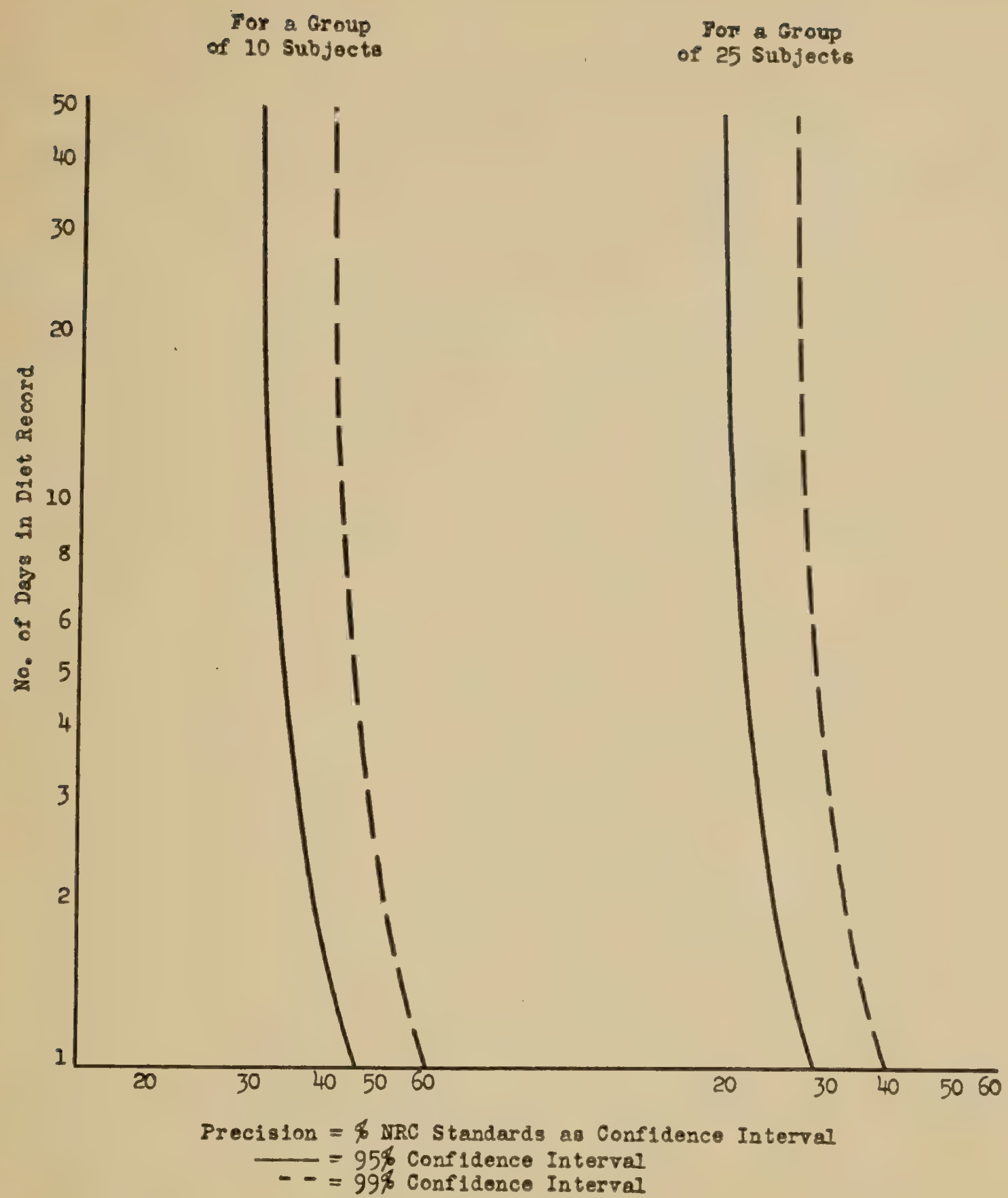

FIGURE 4

Precision vs. number of days in a dietary record for two small groups for calories, protein, calcium, phosphorus, iron, thiamine, riboflavin, and niacin.

DISCUSSION

For an estimate of the mean intake for a group, the use of a one-day record rather than a three-day record obviously represents great savings in time, money, and personnel. Anyone who has actually attempted to obtain the cooperation of a group in keeping a seven-day record, translated the

foods into nutrient quantities, and computed the desired averages, will appreciate the efficiency implied in this conclusion. In addition, there is a great advantage in having a knowledge of the degree of precision which on the average can be assumed in characterizing diets in population types similar to these.

A further implication is psychologic in nature. A group of subjects instructed to keep a one-day record may subconsciously eat a better diet than usual, thus introducing a bias, which would void the results of the survey. If this is an important objection, the method of 24-hour recall might be substituted for the one-day record. In a comparison of seven-day record and 24-hour recall (51), it was found that one method might be substituted for the other under certain conditions. From this conclusion, it seems reasonable to assume that a one-day record and a 24-hour recall would be substantially equivalent, especially if the recall were taken by a trained interviewer.

Summary

To answer the question — how many and which days should be used in a dietary record — seven-day records were taken for junior high pupils in Maine and New York, pregnant women in Massachusetts, high school and college students in Rhode Island and West Virginia, and industrial workers in New Jersey, along with 28-day records and 14-day records on miscellaneous mature subjects at New York and Massachusetts, respectively. The seven-day records were a part of the data collected by these six stations cooperating in the Northeast regional project on "Nutritional Status."

For characterizing a group by its mean intake, a one-day record was found to be the most efficient when the relative importance of the number of days was compared to the number of subjects. A graph is presented from which the number of subjects necessary for a given precision could be estimated. On the average, it was immaterial which day was chosen, since no "day effect" could be discerned with the exception of a college group which seemed to have an understandably lower intake over the week end. It is recommended before surveying any particular group that this conclusion for "which day" should not be assumed without investigation.

On an individual basis, the number of days needed for a desired degree of precision is given in the form of a logarithmic graph.

For groups of ten and twenty-five subjects, logarithmic graphs are presented indicating the increase in precision when the number of days in the dietary record is increased from one to fifty.

The methods in the statistical analyses are outlined briefly in the Statistical Appendix on page 86.

WEEKLY VARIATION OF NUTRIENT INTAKE

Charlotte M. Young, Ruth E. Franklin, Walter D. Foster, and Betty F. Steele

The present investigation was undertaken to study the weekly variation in nutrient intake of a group of young adults during one season of the year. Previous studies in this geographic area in a much more rural community have failed to show seasonal effects on nutrient intake except in vitamin A. The vitamin A available in the spring was substantially less than that available in the fall, but still exceeded the Recommended Dietary Allowances of the National Research Council (52). For school children in three locations in New York State with populations of 750, 1300, and 20,000, respectively, no significant differences were found between fall and spring intakes of the majority of the nutrients either in any one age group or in the groups as a whole (28).

Methods

Subjects Studied

Eighteen individuals, 16 women and two men, were used for the study. Ages ranged from about 23 to 50 years, with a greater concentration in the younger range. The majority of subjects were stenographers and secretaries employed by the University, but there were also a few technical and professional employees as well as a small number of graduate students. In the majority of instances the subjects ate breakfast and dinner at home as part of a family unit and, in general, carried their lunch; a few selected their meals in a cafeteria, and one prepared meals for herself at home (Table 11).

TABLE 11

Description of Subjects Studied

Age in Years	*Number of Subjects*	*Type of Subjects*	*Number of Subjects*	*Place of Meals*	*Number of Subjects*
23–29	10	Secretaries and Stenographers	11	Home (family)	13
30–39	5	Technicians	3	Home (self)	1
40–49	3	Professional	2	Cafeteria	4
		Graduate students	2		

The subjects kept diet records in terms of estimated servings and household measures for 28 consecutive days, from mid-October until mid-November.

Statistical Methods

For each nutrient for each individual, four weekly averages and a 28-day average were computed. Then the weekly averages for each individual were compared to his 28-day average nutrient intake, and the results were expressed in terms of the percentage variation from the longer period average. For each nutrient, the distribution of the percentage deviations from the 28-day averages were studied and summarized.

In addition, by means of the analysis of variance (49) the sources of variation in the nutrient intakes of the 18 individuals over the 28-day period were examined.

Results and Discussion

Variation of Weekly Averages from 28-Day Average

Usually it is not possible to follow the nutrient intake of individuals for as long as 28 days; a seven-day record is apt to be the maximum period for which most subjects may be depended upon to keep records. Consequently, it was of interest to see how the four weekly averages for each individual varied from the average nutrient intake of the entire 28 days. For seven of the ten nutrients studied, approximately 50 per cent of the individuals had weekly averages that varied within ±10 per cent of their 28-day averages for all four of the weeks. The nutrients included calories, protein, phosphorus, iron, thiamine, riboflavin, and niacin. For three of these nutrients (calories, protein, and iron) almost 100 per cent of the individuals had weekly averages that fell within ±20 per cent of their 28-day averages. For the remaining four nutrients (phosphorus, thiamine, riboflavin, and niacin) approximately 85 per cent fell within ±20 per cent of the 28-day averages.

The intakes of vitamin A and ascorbic acid, as might be expected, showed the greatest variation from week to week. For vitamin A, more than 75 per cent of the individuals had weekly averages that deviated more than ±20 per cent from their 28-day averages; for ascorbic acid, more than 40 per cent were in excess of ±20 per cent. Calcium was the next most variable nutrient with about one-third of the individuals having weekly averages varying in excess of ±20 per cent.

In Table 12 are given maximum positive and negative percentage deviations of the weekly averages of individuals from their 28-day averages.

TABLE 12

Maximum Percentage Deviation of Weekly Averages from 28-Day Averages

	Calories	*Protein*	*Calcium*	*Phosphorus*	*Iron*	*Vitamin A*	*Thiamine*	*Riboflavin*	*Niacin*	*Ascorbic Acid*
High +	21	24	38	28	22	105	28	38	38	122
Low −	19	24	40	22	20	69	18	30	25	45

TABLE 13

ANALYSIS OF VARIANCE ON TEN NUTRIENTS FOR TWENTY-EIGHT-DAY RECORDS FOR EIGHTEEN INDIVIDUALS

		Calories in 10's	*Proteins gm.*	*Calcium gm.*	*Phosphorus gm.*	*Iron mg.*	*Vitamin A 100's I.U.*	*Thiamine mg.*	*Riboflavin mg.*	*Niacin mg.*	*Ascorbic Acid mg.*
Source	df	MS	MS	MS	MS	MS	MS	MS	MS	MS	MS
Weeks	3	5,767 NS	780*	1,864 NS	1,491 NS	0.77 NS	7,008 NS	0.1233 NS	0.2733 NS	4.52 NS	5,479 NS
Days	6	6,172 NS	339 NS	1,392 NS	1,249 NS	25.10 NS	15,667 NS	.1617 NS	1.2517**	14.19 NS	3,937 NS
Individuals	17	55,090**	6,046**	40,430**	34,778**	258.97**	59,293**	1.8359**	11.7318**	147.78**	23,768**
Days × Individuals	102	2,177*	271 NS	929 NS	849 NS	11.37 NS	9,193 NS	.0881 NS	.5308 NS	19.25*	1,599 NS
Weeks × Days	18	2,597*	200 NS	981 NS	579 NS	17.07*	7,665 NS	.0633 NS	.2333 NS	14.31 NS	1,784 NS
Weeks × Individuals	51	1,769 NS	241 NS	1,115*	876 NS	6.80 NS	5,925 NS	.0847 NS	.3682 NS	15.49 NS	2,416*
Weeks × Days × Individuals	306	1,461	216	780	749	9.61	8,404	1.9244	0.4787	14.34	1,503

* Significantly different from zero at the five per cent level.
** Significantly different from zero at the one per cent level.
NS Not significantly different from zero.

TABLE 14

TABLE OF MEANS

		Calories	Protein	Calcium	Phosphorus	Iron	Vitamin A	Thiamine	Riboflavin	Niacin	Ascorbic Acid
			gm.	gm.	gm.	mg.	I.U.	mg.	mg.	mg.	mg.
Weeks	1	1976	71.9	0.960	1.250	10.94	8300	1.081	1.888	11.88	103
	2	1936	66.7	.881	1.186	10.81	9930	1.076	1.835	11.59	93
	3	1842	66.9	.890	1.177	10.86	8510	1.023	1.788	11.42	100
	4	1842	69.7	.882	1.183	10.99	8580	1.028	1.881	11.57	88
Days	Sun.	2012	68.9	.836	1.122	10.53	7770	1.036	1.596	11.49	85
	Mon.	1803	66.0	.875	1.194	10.94	11300	1.031	1.923	11.63	97
	Tues.	1946	72.0	.937	1.244	11.64	9250	1.137	1.935	12.21	103
	Wed.	1990	70.6	.952	1.244	10.95	8670	1.089	1.989	12.04	90
	Thurs.	1834	68.9	.930	1.213	11.50	10230	1.050	1.916	11.22	107
	Fri.	1781	66.9	.944	1.222	9.92	7550	.989	1.861	11.08	95
	Sat.	1927	70.9	.882	1.200	11.22	7380	1.073	1.786	12.08	98
Individuals	1	1679	60.0	.610	.880	8.84	8410	.866	1.384	11.30	79
	2	1403	79.2	1.192	1.484	11.72	10820	1.095	2.396	12.33	132
	3	1679	56.1	1.174	1.274	7.17	7980	.768	1.883	6.39	55
	4	2614	76.7	1.142	1.497	19.32	12860	1.282	2.221	12.67	114
	5	2166	81.4	.981	1.359	13.17	6740	1.400	1.939	13.24	95
	6	2178	65.9	.524	.971	12.17	6630	1.005	1.305	13.22	137
	7	1400	56.7	.591	.818	8.06	3360	.755	1.212	9.66	59
	8	1709	53.0	.742	1.025	9.75	5390	.956	1.262	11.67	60
	9	1408	47.6	.372	.697	8.35	9150	.758	1.251	9.96	55
	10	1558	54.2	.524	.811	8.50	4070	.892	1.058	10.23	66
	11	2294	84.0	1.255	1.596	11.75	13040	1.214	2.558	13.39	90
	12	2544	93.7	1.734	1.809	10.35	7650	1.173	3.060	10.78	133
	13	2226	82.6	1.162	1.520	11.15	8120	1.628	2.580	13.91	97
	14	1919	70.3	.496	1.031	14.05	13340	1.058	1.484	12.64	128
	15	1212	47.1	.472	.722	7.55	3230	.751	.977	9.41	90
	16	1886	77.6	1.120	1.431	12.32	9470	1.193	2.197	13.13	130
	17	2607	89.8	1.321	1.667	13.89	22580	1.359	2.801	16.60	107
	18	1688	67.5	0.914	1.080	7.92	6790	0.868	1.837	9.42	105

Sources of Variation in Nutrient Intake

The variation in the 28-day records for the 18 individuals was analyzed in terms of the source of variation. Table 13 presents the analysis of variance for the ten nutrients. Table 14 gives the means for each nutrient for the breakdown of the sources of variation.

The differences between "Weeks" were not significant for nine of the ten nutrients. Protein was the only nutrient for which the variation from week to week was significant at the five per cent level. From these results it would appear that a one-week sample of the nutrient intake is as good as any of its adjacent weeks. Weekly averages do not appear to vary greatly.

The variation due to "Days" was not significant for any nutrient except riboflavin. Therefore, on the average for a group, the nutrient intake per day tended strongly to be constant for all the days of the week. The interaction of "Weeks by Individuals" was not significant for eight of the ten nutrients; for calcium and ascorbic acid the interaction was significant at the five per cent level. From these results it would appear that the pattern of an individual's intake remains nearly the same from week to week except for calcium and ascorbic acid.

The "Day by Individual" interaction was significant for only two of the ten nutrients, calories and niacin. This gives definite evidence that the individuals tended to eat very similarly from day to day.

The "Weeks by Days" interaction was not significant for eight of the ten nutrients; only calories and iron were significant at the five per cent level. This interaction gives further proof that the days tended to have the same pattern from week to week throughout the four-week period. If there were a day effect (which in view of our results appears unlikely), it would remain essentially the same throughout the four weeks.

As has been our previous experience, vitamin A and ascorbic acid intakes show greater variations than other nutrients. No nutrients except calories seemed consistently to deviate from the patterns previously described.

Summary

Eighteen individuals 23 to 50 years of age, eating largely in their own homes, kept 28-day diet records in terms of estimated and measured food portions. Records were calculated in terms of the average weekly and the average 28-day nutritive value of the dietary intakes of each individual. The variation in weekly nutrient intake and the sources of variation in the 28-day intake were studied.

The weekly intake of calories and of nutrients varied considerably with different nutrients and with different subjects.

On the group basis there would not appear to be sufficient variation from week to week to warrant more than a seven-day record. However, to study the intake of an individual, it would appear that more than a one-week record would be desirable for some individuals.

EVALUATION OF DIFFERENCES BETWEEN INTERVIEWERS IN DIETARY SURVEYS

Helen N. Church, Mary M. Clayton, Lorraine O. Gates, Charlotte M. Young, and Walter D. Foster

The compilation of accurate dietary information on groups selected for study is a complex process, and the results must be subjected to proper statistical analysis before they can be accepted as valid or significant. In any procedure for obtaining statistical information relative to food intake there are a number of sources of variation and possible bias which may affect the results and hence the conclusions to be drawn from the nutrition survey. One of these sources is the possible variations resulting from different interviewers obtaining the food histories. It is with this source, the differences between interviewers, that this report is concerned.

Method

Nature of Data

Three state experiment stations participating in the Northeastern Regional Project (NE-4) offered data suitable for a comparison of interviewers. The nature of these data is indicated in Table 15. At Maine, three interviewers worked as a team in each of two schools; at New Jersey, two interviewers collected data in each of two industrial plants; at New York, the dietary histories in one school were taken by two interviewers.

TABLE 15

Number of Interviewers and Subjects Studied at Three Stations

Station	*Type of Subject*	*Groups*	*Interviewers*	*Subjects*
Maine	Junior high school students	2	3	48
New Jersey	Industrial workers	2	2	284
New York	Seventh and eighth grade pupils	1	2	106
Total		5	7	438

The interviewers' backgrounds were basically the same. It was emphasized that they should be skilled and should have some training and experience in dietary interviewing before collecting data for this project. All the interviewers received the same set of instructions and the same type of briefing (7). In the interview, they obtained the subject's usual pattern of eating and then verified this information by cross-checking from a list of food groups (7, 8). The comparisons here are between interviewers at the same station. The possibility that somewhat larger differences may occur between interviewers at different stations is recognized but cannot be tested statistically with the data available.

Statistical Analysis

The information desired from a study of this type includes a comparison of differences between interviewers, together with an estimate of the individual interviewer's consistency from group to group. Since only one history was obtained from each subject, direct comparison was not possible. The principle of *random sampling* together with *analysis of variance* (34) provided the methods for attaining the objectives of this study and have been used in the treatment of these data.

To establish a basis for comparison of differences between interviewers, a random sample of subjects from each group was obtained for each interviewer. In following this method the difference between samples is expected to be zero. Differences greater than sampling variations would then be attributable to the interviewers.

With the data from the five groups listed in Table 15 analysis of variance studies were made on the average daily intakes of calories, protein, iron, and thiamine. These nutrients were selected because they showed the least variation within groups, thus affording more concise comparisons of the interviewers. Previous investigation (72) had indicated that these nutrients were sufficiently representative of the variation found in calories, protein, calcium, phosphorus, iron, thiamine, riboflavin, and niacin; however, two nutrients, vitamin A and ascorbic acid, required separate consideration. Since these last two nutrients are not so well estimated as the others in the usual measurements of dietary intake, the analysis here was restricted to the four nutrients.

Power of the Test

In statistical analysis, one is usually concerned with the probability of finding a significant difference under the hypothesis that no real difference exists. This probability is customarily set at 0.05 (one chance in 20) or 0.01 (one chance in 100). The power of the test is related to the probability of failing to indicate as significant a true difference (53). The higher the power of the test, the less is this chance of failing to obtain significance when a real difference exists.

Results and Discussion

A summary of the analyses of variance together with the means for interviewers is presented in Table 16. Here, the coefficients of variation (*C.V.*) were included to show the relative variation in the data for the nutrients under consideration and for the types of subjects represented in this study. The percentage difference indicates differences between interviewers at each station relative to NRC allowances (73). Since separate analyses for each sex were not made, an average of the NRC allowance was computed, weighted according to the numbers of each sex. Since there are three interviewers in Maine, the range as well as the average percentage is included.

The values under M and N should be studied in pairs. If a value under M represents the real difference between interviewers in percentage of NRC allowance, then the corresponding value under N indicates the power of the test, that is, the probability of indicating significance. For purposes of comparison, the N column in each analysis includes the value of 0.70 with the corresponding percentage under M. This may read as follows: a true difference of M per cent would be found significant in 70 out of 100 samples of this size. In this report the probability level for significance was set at 0.05.

The results of the analyses of variance will be discussed by states. At Maine, the average differences between interviewers, relative to NRC recommended daily allowances, remained less than 10 per cent for each of the nutrients considered. These variations were found to be not significantly different from zero when compared to the variations of subjects interviewed by each nutritionist. Differences between schools were very small, but the relative consistency of interviewers from school to school was virtually the same as the consistency of any one interviewer in one school. It should be noted that differences as large as seven or eight per cent would have been found significant if there had been available a larger number of randomly selected subjects for comparison. For the size of the groups available at Maine, actual differences of about 30 per cent between interviewers would have been necessary to show significance as often as 70 times in 100 samples.

At New Jersey, there were differences between interviewers of 0.7 per cent and 1.3 per cent, respectively, for calories and protein. Real differences of 7.7 and 9.4 per cent, respectively, would have to exist to obtain significance as often as 70 times in 100 samples of the size used. For iron and thiamine, the differences between interviewers were 9.2 and 7.3 per cent, respectively. These differences are statistically significant, although the power of the test indicates values of 10.6 and 8.7 per cent, respectively, to expect significance in 70 of 100 samples. Thus, the actual percentage differences between interviewers are of the same order of magnitude as at the other stations but, because of the larger number of subjects at New Jersey, these differences were found to be significant with regard to two nutrients. Although large plant differences existed, i.e., differences from plant to plant, for calories and iron; the interviewers tended to maintain their relative effect from plant to plant in all nutrients.

Differences of 2.1 and 2.4 per cent for calories and protein, respectively, were found at New York. Thiamine showed a 3.6 per cent difference between interviewers. The difference of 8.0 per cent for iron undoubtedly would have been significant had the number of subjects closely approached that at New Jersey.

From a study of Table 16, it appears that the differences between interviewers would not significantly alter the results of a dietary survey. Actually, the errors are small compared to those often observed between methods of obtaining dietary information, for example, the history and the

TABLE 16

ANALYSIS OF VARIANCE, INTERVIEWER MEANS, AND POWER OF THE TEST

		Calories in 10's		*Protein gm.*		*Iron mg.*		*Thiamine mg.*	
MAINE	*df*	*MS*		*MS*		*MS*		*MS*	
Interviewers	2	2,119 *NS*		546 *NS*		18.70 *NS*		.0825 *NS*	
Schools	1	2,241		140		5.42		.0251	
Interviewers × Schools	2	7,492 *NS*		878 *NS*		20.52 *NS*		.2120 *NS*	
Within	42	5,936		738		17.17		.1821	
C.V.		26.0%		28.4%		25.0%		26.1%	
Interviewer Means	A	285		89.2		15.7		1.56	
	B	297		96.8		17.8		1.65	
	C	308		100.8		16.1		1.70	
Per Cent Difference:	Average	5.3%		9.4%		9.3%		6.7%	
(NRC)	Range	3.8–7.9		4.8–14.1		2.7–14.0		3.6–10.0	
		M	*N*	*M*	*N*	*M*	*N*	*M*	*N*
Power of the Test		5.0	—	5.0	—	5.0	—	5.0	—
		10.0	.10	7.7	—	7.7	—	5.6	—
		26.2	.70	10.0	.03	10.0	.06	10.0	.06
				31.7	.70	28.1	.70	28.9	.70
NEW JERSEY	*df*	*MS*		*MS*		*MS*		*MS*	
Interviewers	1	493 *NS*		62 *NS*		84.2*		.857*	
Plants	1	30,768		549		150.9		.167	
Interviewers × Plants	1	1,141 *NS*		26 *NS*		15.1 *NS*		.232 *NS*	
Within	280	5,663		497		18.5		.156	
C.V.		26.5%		24.6%		26.5%		25.5%	
Interviewer Means	D	285		91.0		16.8		1.60	
	E	283		90.1		15.7		1.49	
Per Cent Difference (NRC)		0.7%		1.3%		9.2%		7.3%	
		M	*N*	*M*	*N*	*M*	*N*	*M*	*N*
Power of the Test		5.0	.38	5.0	.27	5.0	.20	5.0	.35
		7.7	.70	9.4	.70	6.9	.39	7.4	.63
		10.0	.89	10.0	.75	10.0	.65	8.7	.70
						10.6	.70	10.0	.86
NEW YORK	*df*	*MS*		*MS*		*MS*		*MS*	
Interviewers	1	734 *NS*		88 *NS*		39.33 *NS*		.066 *NS*	
Within	104	7,189		710		19.65		.206	
C.V.		27.5%		26.6%		27.6%		26.9%	
Interviewer Means	F	311		99		16.7		1.72	
	G	305		101		15.5		1.67	
Per Cent Difference (NRC)		2.1%		2.4%		8.0%		3.6%	
		M	*N*	*M*	*N*	*M*	*N*	*M*	*N*
Power of the Test		5.0	.10	5.0	.03	5.0	.07	5.0	.06
		10.0	.47	10.0	.34	7.8	.27	10.0	.40
		13.3	.70	16.0	.70	10.0	.42	14.6	.70
						14.2	.70		

Explanation of Symbols

C.V. Coefficient of variation
df Degrees of freedom
A-G Interviewers
* Significant at the five per cent level.

M Per cent difference (NRC)
N Power for significance at .05
MS Mean square
NS Not significant

record (50). Moreover, these differences carry even less significance when viewed in terms of nutritional status, where there remains a large and difficult task of accurate measurement. As indicated by the data given in Table 16, interviewer differences of five per cent of the N.R.C. Allowances are not likely to exceed sampling variation in groups of less than 50 per interviewer.

Summary

Dietary survey data collected by seven interviewers on 438 randomly sampled subjects were analyzed for differences due to the interviewers. These differences between interviewers in this study rarely exceeded 10 per cent of the N.R.C Allowances for each nutrient (average 5.4 per cent). It was concluded that interviewer differences of five per cent are not likely to exceed sampling variations in groups of less than 50 subjects per interviewer.

COMPARISON BETWEEN THREE METHODS OF ASSESSING NUTRIENT INTAKE OF CHILDREN

SEVEN-DAY RECORD, INTERVIEW WITH THE CHILD, AND INTERVIEW WITH THE MOTHER

Betty F. Steele, Vivian L. Smudski, Ruth E. Franklin, and Charlotte M. Young

Dietary data on children one through ten years of age indicated that the best dietary history after seven-and-one-half years of age was obtained by questioning both the mother and the child (54). These data were collected by Beal *et al.* whose work was mainly concerned with the estimation of caloric intake. This study was undertaken to compare three methods of obtaining dietary information on the intake of ten nutrients by adolescents; these methods are seven-day record, interview with the mother, and interview with the child.

METHODS

Eighth grade pupils (eleven boys and eleven girls from thirteen to seventeen years of age) and their mothers from a rural community participated in this study. During the spring of 1948 a trained nutritionist obtained a history of a typical weekly dietary intake from the child and at another time from his mother. Each interview took from one to one-and-a-half hours. Neither the child nor the mother was forewarned that such a dietary history was going to be taken nor did either know the other member of the family was going to be questioned. By these means it was hoped to eliminate any preconditioning of the subjects. Seven-day records of foods eaten were kept after the interviews by each child. The nutrient intakes obtained by these three methods were compared by calculating the standard deviation of the individual records about the mean. The means and standard deviations were tested for significance by Student's t (49).

RESULTS AND DISCUSSION

The mean dietary intakes with their standard deviations for ten nutrients as calculated from the seven-day records, the child's interview, and the mother's interview are given in Table 17. The seven-day records kept by the boys gave values of nutrient intakes that were lower than those obtained by the other two methods. The boys' interviews gave higher values of nutrient intake than was evident from the mothers' interviews. The seven-day records for the girls gave lower intake values than were found for the two interview methods; however, the interviews for the girls and their mothers gave values more nearly alike.

TABLE 17

COMPARISON BETWEEN THREE METHODS OF ASSESSING NUTRIENT INTAKE: SEVEN-DAY RECORD; INTERVIEW WITH CHILD; AND INTERVIEW WITH MOTHER.
TWENTY-TWO SUBJECTS

Nutrients	Boys Mean and S.D.*						Girls Mean and S.D.*					
	7-Day Record		Child's Interview		Mother's Interview		7-Day Record		Child's Interview		Mother's Interview	
Calories	2478	65	3538	185	3325	216	1972	47	2898	153	2803	148
Protein, gm.	98	7.4	120	6.1	112	4.8	69	3.3	90	4.9	92	5.2
Calcium, mg.	1439	30	2093	171	1723	151	964	71	1437	84	1497	123
Phosphorus, mg.	1836	174	2562	162	2215	123	1257	57	1859	97	1839	98
Iron, mg.	15.3	1.2	19.0	1.7	17.4	1.3	10.6	0.6	14.7	1.0	13.4	0.7
Vitamin A, I.U.	5889	813	10,120	1576	7657	1397	4425	634	8231	892	6564	597
Thiamine, mg.	1.56	.01	2.02	.10	1.88	.14	1.05	.05	2.51	.13	1.46	.08
Riboflavin, mg.	2.80	.30	3.56	.26	3.08	.22	1.90	.28	2.51	.14	2.55	.17
Niacin, mg.	14.0	1.6	18.0	1.2	18.0	1.7	9.9	.45	16.2	1.1	15.7	1.9
Ascorbic Acid, mg.	94	20	127	17	102	10	52	7.4	108	12	94	8

* Standard deviation.

The significance of the differences found between the three methods is evaluated in Table 18 by means of Student's *t*. When the seven-day records and the mothers' interviews are compared by this method, it can be seen that the hypothesis that the record and the mother's interview are the same (significant at a $P > 0.05$) is true for all nutrients except calories for the boys, but true only for riboflavin for the girls. This is interesting in view of Eppright's report. Thus, based on this small sample of 11 subjects, the seven-day record and the mother's interview could be used interchangeably for the boys, except for calories; the two methods are not interchangeable for the girls. Comparison between the seven-day record kept by the boys and the boys' interviews did not give such good results. Protein, calcium, phosphorus, and vitamin A estimates were statistically different by the two methods. The girls did even poorer, nine of the nutrients estimated yielding *t* values equal to or greater than a *P* of 0.05.

TABLE 18

Comparison between Three Methods of Assessing Nutrient Intake of Children: Test of Significance

	t value (10 degrees of freedom)					
Nutrients	*Seven-day record and mother's interview*		*Seven-day record and child's interview*		*Mother's interview and child's interview*	
	boys	girls	boys	girls	boys	girls
Calories	3.75**	5.34**	1.08	5.77**	0.75	0.45
Protein	1.59	3.73**	2.29*	3.73**	1.03	0.28
Calcium	1.84	3.76**	3.76**	4.31**	1.62	0.40
Phosphorus	1.78	5.14**	3.05*	5.38**	1.70	0.14
Iron	1.20	2.92	1.77	3.50**	0.75	1.06
Vitamin A	1.16	2.45*	2.39*	3.48**	1.17	1.55
Thiamine	0.58	4.61**	1.02	10.28**	0.76	6.84**
Riboflavin	0.76	1.96	1.90	1.93	1.39	0.18
Niacin	1.75	2.97*	2.03	5.34**	0.0	0.23
Ascorbic acid	0.35	3.82**	1.25	3.99*	1.48	0.97

* Significant at $P \leq 0.05$, but > 0.01
** Highly significant at $P \leq 0.01$

When the results of the mother's interview were compared with the results of the child's interview, all *P* values, except for thiamine (girls), were less than 0.05. Thus, except for this one nutrient, it would seem these latter two methods could be used equally well in assessing nutrient intake of the adolescent.

Summary

The dietary intakes of 22 adolescents, 11 boys and 11 girls, were estimated by three methods; namely, seven-day food record, interview with the child, and interview with the mother.

The seven-day records gave lower estimations of nutrient intake for both boys and girls than were found by the interviews.

When evaluated by Student's t, the seven-day records and the mother's interviews, for the boys, gave values having a P value lower than 0.05. Values for the girls determined from these two sources usually exceeded a P of 0.05.

The results between the mother's and the child's interviews gave values of P lower than 0.05 for all nutrients except thiamine (girls).

USE OF CHECKED SEVEN-DAY RECORDS IN A DIETARY SURVEY [1]

Betty F. Steele, Ruth E. Franklin, Vivian L. Smudski, and Charlotte M. Young

In this study, 87 seven-day dietary records were kept by boys and girls in the seventh and eighth grade. The food record was then checked by a nutritionist in an interview with the subject. The nutritive values of the checked and unchecked dietaries were calculated for nine nutrients.

When results for the 87 children were averaged, the unchecked dietaries gave no differences greater than 10 per cent of the checked records for the nutrients calculated. However, 16 per cent of the subjects had unchecked records that deviated 10 per cent or more from the checked records. Consequently, when the nutrient intake of the individual is desired, it would seem wise to devote the brief time required to check the recorded food intake with the individual.

[1] Published in its entirety in the *Journal of the American Dietetic Association*, 27 : 957 (1951).

SUBJECT'S ABILITY TO ESTIMATE FOOD PORTIONS

Charlotte M. Young, Faith W. Chalmers, Helen N. Church, Mary M. Clayton, Gladys C. Hagan, Betty F. Steele, Ruth E. Tucker, and Walter D. Foster

There are many sources of possible errors in dietary studies. One great source might be eliminated if all dietary intakes could be studied on a weighed basis. In many investigations, weighing food samples is neither possible nor necessarily even desirable. Many feel that a more accurate picture of usual dietary intake is obtained if the subject is instructed to estimate his intake in terms of servings or of household measures, actually measuring portions whenever possible. The element of estimation introduces an error of unknown quantity; it may be large or small, depending on the subject's ability to estimate accurately the size of food portions eaten. Not only is there this factor, but also the element of carefulness and conscientiousness in using the ability to its utmost. The subject's ability and willingness to estimate his food portions accurately may be the largest factor in the accuracy of the unweighed food record. Effects of the method of collection of dietary data as well as the time, season, and interpretations of dietary calculations contribute to inaccuracies in estimating nutrient intake and may be of less significance.

To interpret results of dietary studies based on estimations, one should have some idea of the error introduced into findings by the subject's ability to estimate size of portions. It is quite possible that the ability to estimate food portions accurately may vary with age, educational level, acquaintanceship of the subject with food and familiarity with food handling, and even with the conscientiousness of the subject. Since the present project involved individuals from five to sixty-five years of age and of educational levels from the lower grades through college, as well as individuals accustomed to handling food daily (pregnant women) and those who probably have little to do with food other than consuming it, it seemed an excellent opportunity to study the ability of diverse types of subjects to estimate food portions. The present experiments were designed to obtain information on the following problems for each type of subject studied:

1. Difference between actual and estimated portions
2. Direction of bias in estimated portions
3. Variation in the individual estimates or the relationship between actual and estimated portions
4. Effect of failure to report all foods eaten — omissions

There are certain very real limitations to this study. In most instances it was not possible to undertake the study during the regular collection of

dietary data. Separate small studies had to be made, which often could not duplicate the circumstances under which the dietary data were originally collected. It was better to get some estimation rather than to ignore this source of error completely. However, since it was not possible to duplicate previous procedures, results presented here are not necessarily directly applicable to dietary data already collected.

Methods

Collection of Data

Ideal Method

There are many difficulties in collecting data of this kind to suit the objectives already outlined. Ideally, such a method would proceed as follows. First, the subjects should be typically representative of the population from which the dietary studies have been or are to be drawn. They should also be given the same instructions as other persons in the study for fulfilling the seven-day dietary record. Perhaps this particular study might be made simultaneously with the taking of data from ordinary subjects. It is imperative that the subjects be entirely unaware of the fact that their food and their uneaten portions have been measured and that their dietary intake has been checked. Furthermore in this ideal type of study, the units or dimensions to describe the amounts should be simple and easy to use. They should be the same for all the subjects on whom dietary measurements are being taken and should be defined so completely and basically that there would be no room for misinterpretation or misunderstanding. Very often the wrong units can defy any degree of accuracy. Obviously, it is necessary to have an accurate measurement of the portions actually served on the plates, whether the measures are cups, tablespoons, or ounces. Even though it has been observed that most adults tend to eat almost everything on their plate, children especially in junior high school might tend to trade the food on their plates, one person switching a serving of certain food for another, especially in fruits or desserts. Observation of such switches or changes should be made and duly noted. Any unused portions of the servings should be accurately measured and subtracted from the original serving to indicate exactly how much a subject ate and to afford a valid comparison to his report on his seven-day record.

Pursuing the ideal further, it would be necessary to observe every meal for a week to make a complete appraisal of the seven-day record itself. Such a study would offer a measure of the trend of the subject's accuracy throughout the week, thus affording an objective basis for further decisions in the use of the dietary record (72).

Methods Used — Compromise with Practicality

Difficulties in obtaining these data according to this procedure are immediately seen to be almost insurmountable. The efforts to observe three

meals a day for some subjects, particularly the children in junior high and high schools, where most of the meals are eaten at home, offered a great obstacle. That their eating habits might be observed at home without their knowledge is a second barrier, especially because left-overs from the served portions would have to be measured. It might be suggested that cooperation with the mother in the home in making the necessary measurements could be obtained. In some trials it was found difficult to conceal these activities from the subjects themselves. Mothers would often reveal the secret as early as the first meal to the subject, thus vitiating a basic requirement of this study.

In collecting data for this particular study, it was impossible to follow a consistent or identical routine since the subjects at every station varied in age and environment. Although the ideal method of collecting data was adhered to as closely as possible under practical conditions, deviations from the ideal will be noted in the description below.

At Maine, 25 to 30 eighth and ninth grade students were observed on three consecutive days at school luncheon, where servings were measured before they were given to the subjects. It was noted when the subjects neglected to record some of the food consumed. They were then questioned so that there were few instances of omissions in these figures. Since it was necessary that the supervisors of the study be on hand to observe unused portions of food, there was no doubt that the subjects knew that they were being observed.

At Massachusetts a different situation existed. The pregnant women were shown specially prepared trays containing sample meals. As housewives, it would be impossible to observe them without revealing the intent of the study. Each one was asked to estimate the amount of food on each tray and to report it. Since the amounts of food had been measured before preparing the trays, a direct comparison was offered in this manner. Although under ordinary circumstances estimation of food when the subject realizes he is being watched may be more accurate than otherwise, the reverse may be true for the subjects at Massachusetts. In the original dietary records, these housewives had been measuring the food for the first several days so that they had become quite efficient at estimating the amounts they had been eating. In this way the experimental procedure would in no way estimate the accuracy of the seven-day records obtained from the pregnant women in Massachusetts. Rather, it would be an indication of their ability to estimate after a considerable lapse of time from the taking of the original records.

At New Jersey, as part of the original survey, industrial workers were asked to keep seven-day records many of which included lunch at the plant cafeteria. Since the size of servings from the cafeteria had been measured and recorded, data from those original records were available. Forty-eight of these records were suitable for this study. Although data from only one meal were available by this method, it does represent the conditions under

which the original seven-day records were taken. On the other hand, there was no way of indicating how much food was left on the dishes nor of knowing when the worker failed to report everything he had eaten. Thus, there are two possible sources of bias, although it has been a common observation that workers eat everything on their plate.

Sixteen grade school subjects at New York were observed while eating one school lunch where the amount of food served was estimated by a panel of three advisors from the Home Economics Department. Directly after the meal these subjects were questioned about kind and amount of food each had on his tray. If there were omissions, the subject was reminded that he had neglected to indicate certain foods. The circumstances here were not comparable to a record made by the child at the time of eating.

At Rhode Island, 18 girls, representative of the home economics students there, were studied for three days during which time they recorded food intake. Any unused food on the trays was recorded and subtracted from the original servings. It was believed that the subjects were unaware of the intent of the experiment or that they were being observed.

At West Virginia, 23 college students in the Infirmary were observed for breakfast, luncheon, and dinner during which period they were asked to record their food intake. The food served to these subjects was accurately measured, and the unused portions subtracted; failure to report all foods eaten was noted. In addition, the subjects were completely unaware of the intent of the experiment or that their eating habits were being observed. It was felt that subjects may be considered as representative of the college students as a whole, although it would not be possible to compare these results directly with the original seven-day records obtained from the college students at West Virginia. No subjects too sick or weak to eat a regular meal were selected, so that any effects of illness were hoped to be minimized.

Analysis of Data

Statistical methods employed to answer the four questions raised in this study were the mean, per cent difference, tests on differences between means, coefficients of variation, and regression and correlation.

At first it was thought best to divide the foods by the units by which they were measured, such as cups, cubic inches, ounces, tablespoons, and teaspoons, and to make comparisons in the units as they appeared. It was decided further to break down the meals into breakfast, luncheon, and dinner so that some measure of consistency and accuracy for the different meals could be compared. To broaden the scope of this study, it was suggested that the various foods themselves be classified into meat and fish; vegetables and salads; pudding, sauce and gravy; casserole; soup; sugar; pie and cake; beverage; bread dressing; and item foods.

Results for each station are reported in Table 19 by food type. Breakfast, luncheon, and dinner are identified by checks, and N represents the number

of the subjects for a particular classification. The next column lists the units of measure. The next two columns list the actual mean and the reported or estimated mean followed by the per cent difference with regard to the actual consumption. Where the range of the amount of food eaten was sufficient, the regression of reported intake on actual intake was computed, giving an estimate of the linear relationship (if it exists) between actual and reported intake on an individual basis. The correlation, as an index of the clustering of the points to this regression line, is given in the next column. The coefficient of variation was computed as the standard deviation of the reported values divided by the mean of the actual values. This statistic is an indication of the variation in estimates relative to size of the serving and should be used with the percentage difference between actual and reported values as a criterion for comparison. In the column describing the effect of omissions, where both *W* and *WO* are checked simultaneously, it is meant that there were no omissions in reporting the food eaten. In those cases where some foods were eaten but not reported, the analysis was made both with and without these omissions to show the bias of omission. Column *W* refers to calculations in which omissions were treated as zero intake. Column *WO* refers to calculations made on only the reported foods.

If there were a distinct one-for-one correspondence in the units to measure food, i.e., the larger the serving the larger the recording of it, then we should expect the regression of coefficients to be unity. That they failed to be unity is given by a test of significance in which the values of b are starred or double-starred as they are significantly different from unity. If they are not starred, their difference from unity was not detectable. When the individuals without exception reported the same amount as actually served, the notation $A = R$ was entered, and no further computations made for the following reasons. If the means were equal, there was no percentage difference, the regression coefficient was unity, the correlation coefficient was unity, and the coefficient of variation was zero.

Results and Discussion

Difference Between Actual and Estimated Portions

In Table 19 is summarized the comparison of the mean estimated or reported and the actual food intakes by food type and by station (type of subject).

Comparison by Type of Subject

For some food types it is not possible to make comparisons between the abilities of the various types of subjects to estimate food portions, since not all food types were estimated by all types of subjects. However, certain general impressions are possible. The Rhode Island college students were by far the best estimators of food portions as measured by the difference be-

tween actual and reported means expressed as a percentage of the actual mean. For many food types, especially meats, vegetables and salads, puddings, soup, sugar, bread and rolls, cookies, eggs and butter, the actual and reported means were equal or almost equal. These subjects were Home Economics students and were well accustomed to estimating food portions. The results with West Virginia college students indicate that such accuracy of estimation is not necessarily characteristic of all types of college students, since their differences between actual and reported means for most food types were as great as for other types of subjects.

The number of food types included in the estimations made by the pregnant women from Massachusetts was more limited than for the New Jersey male industrial workers. However, for the food types estimated by both groups, the women homemakers in general reported mean estimates nearer to the actual means than did the men. This greater accuracy may reflect the experience of the women in measuring food quantities. Actually, the male industrial workers seemed to report estimates for some food types which were closer to the actual food portion size than did the college students of West Virginia.

The junior high school children, in general, made the poorest estimations of food portions. However, for certain food types, especially meat, vegetables and salads, beverages, bread and rolls, and cookies, the Maine children did particularly well. It should be remembered that the subjects were aware that they were being observed, since the supervisors of the study were on hand. It does show that the children were capable of estimating certain food types quite accurately; it does not tell us whether this would be their customary performance when not under surveillance.

Meredith *et al.* (27) found that on their third day of study, when children knew they were being checked, there was better agreement between intake obtained by recall and that obtained by weighed diets.

The New York junior high students made the poorest estimations of all types of subjects for all types of foods included in their menus. It will be remembered that in this study, recall, not records, was employed after the meal. The children were completely unaware of observation or that any study was being conducted until each was interviewed after the meal. The present study does not indicate how accurately the children would have estimated portions of food if they had been making records as they ate the food portions. Earlier reports indicated that the dietary histories reported by New York children (as well as Maine children) gave nutrient estimations 25 to 35 per cent higher than those obtained from diet records (50). However, on a group basis the 24-hour recall and seven-day records gave similar estimates of nutrient intake (51).

Comparison by Type of Food

The food types differed in the accuracy with which sizes of portions were reported. The food types that were generally reported most accurately

were sugar, soups, item meats, bread and rolls, cookies, and eggs. It will be noted that these are foods that, in general, may be counted as items or that may be easily estimated. The food types reported least accurately in quantitative terms were those grouped as "puddings," sauces and gravies, and fruits. Meats, butter, and vegetables and salads fared remarkably well considering the difficulty in estimation, which is usually assigned to these foods. It is interesting that the group of foods classified under "casseroles" were well estimated by the Maine children and the New Jersey male workers, yet they were estimated more poorly than any other food group by the Rhode Island Home Economics students and very poorly by West Virginia college students, even more poorly than the New York junior high school students. Pies and cakes were one of the more difficult food items for most of the types of subjects to estimate accurately.

It was difficult to make comparisons between types of subjects on the basis of types of foods, since within the food groups considered, the difficulties of estimation vary greatly. An item piece of fruit was easy to report, but portions of whole fruit and diced up fruit were much more difficult.

Comparison by Unit of Measure

Since the problem of which units should be employed in measuring the different foods is one of primary importance, it is of interest to note that, for meats, the coefficient of variation for cubic inches seems to be much higher than for other measures. Both West Virginia and New Jersey have reported some meat in cubic inches, for which the coefficients of variation were 72.7 and 45.7, respectively. On the basis of the result in New Jersey, it would appear that ounces were a better measure in which to estimate meat than cubic inches, despite the percentage difference between actual and reported means of only 3.3 per cent for the latter. Maine with 27 subjects had the lowest coefficient of variation of all stations by recording meat in terms of cups. It should not be overlooked that West Virginia's subjects measuring meat in tablespoons had low percentages of difference, and the coefficient of variation of 26.0 per cent was not excessively high.

For other food types, wherever the food could be reported in terms of numbers of items, the mean reported estimate was closer to the actual mean.

Direction of Bias in Estimated Portions

For all types of food and for all types of subjects there were both overestimations and underestimations in sizes of food portions. However, by a count of the number of times subjects overestimated their servings in contrast to the number of times they underestimated them, there is evidence of considerable bias in the direction of overestimation. That this bias is partially compensated by the omissions noted in data, where records of omission were available, can be seen in the fact that many original cases of overestimation became underestimation when zero was used in the calculation of the means (Table 19).

TABLE 19

SUMMARY OF SUBJECT'S ABILITY TO ESTIMATE FOOD PORTIONS (BY FOOD TYPE)

State	Meal B	Meal L	Meal D	N	Unit	Mean Actual	Mean Reported	Differences as % of Actual	b	r	Coeff. of Variation	Effect of Omission W.	Effect of Omission W. O.	Estimate
Meat and Fish														
Maine		X		27	Cups	1.00	.926	7.4%*			18.1%	X	X	Under
N.J.		X		7	Cu. in.	4.171	4.035	3.3%	.595	.356	72.7%	X	X	Under
		X		21	Oz.	3.452	3.831	11.0%	.738	.637	33.5%	X	X	Over
R.I.		X	X	12	Item	$A = R$						X	X	
W.Va.		X		11	T	6.273	6.455	2.9%**	.373**	.621*	26.0%		X	Over
					T	5.778	5.917	2.4%				X		Over
		X	X	19	Cu. in.	2.432	3.046	25.2%*	.488*	.549*	45.7%	X	X	Over
			X	4	T	5.000	6.500	30.0%	.833	.870	38.3%	X	X	Over
		X		2	Slices	2.625	1.500	42.9%	.1334	—	27.0%	X	X	Under
Vegetables and Salads														
Maine		X		27	Item	$A = R$						X	X	
		X		24	Cups	.667	.646	3.1%			24.6%	X	X	Under
Mass.		X		179	T	8.737	8.397	3.9%			49.2%	X	X	Under
N.J.		X		60	T	5.435	6.916	27.2%	1.257	.684	88.4%	X	X	Over
N.Y.		X		16	L. Leaf	1.0	1.406	40.6%*			61.1%	X	X	Over
R.I.		X		25	Cups	$A = R$								
			X	16	T	5.875	6.375	8.5%			54.8%		X	Over
			X		T	6.211	5.368	13.6%				X		Under
W.Va.		X		40	T	5.596	5.771	3.1%**	.322**	.243	57.3%		X	Over
					T	5.285	3.912	26.0%				X		Under
			X	60	T	4.683	5.633	20.3%*	.599**	.417**	58.5%		X	Over
					T	4.420	4.899	10.8%				X		Over
Puddings (Including also breakfast cereals, cheese, and ice cream)														
Maine		X		19	Cups	.333	.519	55.9%**			69.7%	X	X	Over
		X		15	Cups	.500	.633	26.6%*			41.6%	X	X	Over
Mass.		X		151	Cups	.579	.692	19.5%*			68.0%	X	X	Over

N.J.		X		11	Cups	.442	.555	25.6%	1.096	.584	56.8%	X	X	Over
R.I.		X		2	Cups	$A = R$						X	X	
			X	10	Cups	$A = R$							X	
			X	10	Cups	.511	.466	8.8%				X		Under
W. Va.			X	20		.325	.521	60.3%	−.204	−.070	76.3%		X	Over
					Cups	.318	.434	36.5%				X		Over
		X		25		.335	.414	23.6%	.458**	.223	63.9%		X	Over
					Cups	.347	383	10.4%				X		Over
Sauce and Gravy														
Maine		X		25	T	1.00	1.767	76.7%**			113.5%	X	X	Over
R.I.	X				T	2.073	2.635	27.1%			174.3%		X	Over
	X			16	T	2.010	2.480	23.4%				X		Over
		X			T	2.000	1.500	25.0%					X	Under
		X		6	T	1.545	1.273	17.6%				X		Under
			X	8	T	3.000	2.375	20.8%			43.4%	X	X	Under
W.Va.		X	X	13	T	1.154	1.038	10.0%**	.054**	.087	27.7%		X	Under
					T	1.058	.338	68.0%				X		Under
Casseroles (Including baked beans, omelet, chili, stew, macaroni)														
Maine		X		21	Cups	.500	.504	.8%			34.8%	X	X	Over
N.J.		X		11	Oz.	4.818	4.909	1.9%			56.8%	X	X	Over
N.Y.		X			Cups	1.000	1.322	32.2%			101.4%		X	Over
		X		15	Cups	1.000	1.239	23.9%				X		Over
R.I.		X		2	Cups	$A = R$						X	X	
			X	3	Cups	$A = R$							X	
			X			.688	.438	36.3%				X		Under
W.Va.		X	X	8	Cups	.354	.602	70.1%	1.14	.714*	91.0%	X	X	Over
Soups														
N.J.		X		10	Oz.	8.5	9.2	8.2%	1.160	.873	33.2%	X	X	Over
R.I.		X		3	Oz.	$A = R$						X	X	
Sugar														
R.I.		X	X									X	X	
W.Va.			X	3	Tsp.	$A = R$						X	X	

* Significantly diffent from zero at the five per cent level. ** Significantly different from zero at the one per cent level.

TABLE 19 (CONT.)

SUMMARY OF SUBJECT'S ABILITY TO ESTIMATE FOOD PORTIONS (BY FOOD TYPE)

State	Meal B	Meal L	Meal D	N	Unit	Mean Actual	Mean Reported	Differences as % of Actual %	b	r	Coeff. of Variation	Effect of omission W.	Effect of omission W. O.	Estimate
Pie and Cake														
Mass.		X		17	Cu. in.	11.250	13.735	22.1%			60.3%	X	X	Over
		X		15	Sq. in.	9.095	10.126	11.3%			29.2%	X	X	Over
N.J.		X		8	Cu. in.	6.375	7.85	23.1%	1.312	.765	112.1%	X	X	Over
N.Y.		X			Cu. in.	1.000	4.340	334.0%			434.2%		X	Over
				13	Cu. in.	1.000	3.526	252.6%*				X		Over
R.I.		X		8	Cake roll	$A = R$							X	
		X			Cake roll	1.000	.727	27.3%				X		Under
			X	13	Item	$A = R$						X	X	
W.Va.		X	X	9	Cu. in.	4.339	4.250	2.1%	.508	.612	33.1%	X	X	Under
Beverage (Includes milk, tea, coffee, fruit juices, colas)														
Maine		X		83	Cups	$A = R$						X	X	
Mass.		X		85	Cups	.700	.704	.57%			38.7%	X	X	Over
N.J.		X		18	Oz.	7.333	8.75	19.3%**	.774	.942	41.1%	X	X	Over
N.Y.		X		16	Pints	.500	.625	25.0%*			44.8%	X	X	Over
R.I.	X			65	Cups	$A = R$						X	X	
		X		18	Cups	1.000	.857	14.3%				X		Under
		X				$A = R$							X	
			X	34		.757	.777	2.6%			34.6%		X	Over
			X			.780	.629	19.4%				X		Under
W.Va.	X	X	X		Cups	.859	.928	8.0%	.808**	.820**	37.4%		X	Over
	X	X	X	87	Cups	.862	.897	4.1%**				X		Over
Rolls and Bread														
Maine		X		83	Item	$A = R$						X	X	
N.Y.		X			Cu. in.	4.500	5.944	32.1%			43.6%		X	Over
		X		9	Cu. in.	4.500	3.567	20.7%				X		Under
R.I.	X			29	Item	$A = R$						X	X	
		X		13	Item	$A = R$							X	

		X			Item	.964	.893	7.3%				X		Under
		X		13	Item	$A = R$						X	X	
W.Va.		X	X			.949	.962	1.4%	.824**	.947**	14.0%		X	Over
				40	Item	.941	.895	4.9%**				X		Under
	X	X		24	Item	.997	1.042	4.5%	.998	.744**	31.9%	X	X	Over
Cookies														
Maine		X		24	Item	$A = R$						X	X	
R.I.		X		7	Item	$A = R$						X	X	
W.Va.		X	X	6	Item	1.0	1.0					X	X	
Eggs														
R.I.	X			5	Item	$A = R$						X	X	
W.Va.	X			20	Item	.869	1.012	16.5%	.570	.467	32.9%	X	X	
Butter														
Maine		X		26	T	.500	.609	21.8%			67.8%	X	X	Over
Mass.		X		65	Pats	2.085	2.238	7.3%			71.1%	X	X	Over
N.Y.		X			Pats	1.500	.844	43.7%			15.3%		X	Under
		X		8	Pats	1.500	.422	71.9%**				X		Under
R.I.	X	X	X	31	Pats	$A = R$						X	X	
W.Va.	X	X	X		Pats	.951	.985	3.6%	.328	.553	9.4%		X	Over
				33	Pats	.906	.739	18.4%**				X		Under
Fruit														
N.J.		X		4	Item	$A = R$						X	X	
N.Y.		X		16	Pear	.500	.625	25.0%			77.4%	X	X	Over
		X			Apple	.125	.200	60.0%			49.6%		X	Over
		X		11	Apple	.125	.138	10.4%**				X		Over
W.Va.		X	X	8	T	5.750	3.562	38.0%	−.286	−.188	52.5%		X	Under
					T	5.556	3.167	43.0%				X		Under
Item Meat (Includes bacon and frankfurters)														
Maine		X		25	Item	$A = R$						X	X	
N.J.		X		7		4.0	3.857	3.6%	.938	.987	54.8%	X	X	Under
W.Va.	X			22	Sl.	1.773	1.818	2.5%	1.142	.670**	38.5%	X	X	Over
		X		4	Franks	.984	1.000	1.6%				X	X	Over

* Significantly different from zero at the five per cent level.
** Significantly different from zero at the one per cent level.

New York school children overestimated for every food type reported except butter. New Jersey workers overestimated in all items. By food types, the greatest overestimations were for "puddings" and pies and cakes.

Variation in the Individual Estimates

Two of the stations participating in this experiment offered data suitable for examining the relationship between size of estimated portions compared with actual portions reported by individuals. To answer the question of whether individuals tend to overestimate or underestimate portion size as the size increases, the regression of reported portion on actual portion was computed for each food classification and unit of measure (except for the item foods). For foods measured in both cups and tablespoons, the subjects at New Jersey tended to show a slight exaggeration in reporting serving size as the actual size increased. This tendency is seen in the regression coefficients of 1.14, 1.09, and 1.26, all of which exceeded unity, the value for one-to-one correspondence. However, none of these was significantly different from unity. This result may be contrasted with the figures for the subjects at West Virginia, for whom a definite tendency to underestimate portion size was noted as portion size increased. Values of regression coefficients for cups and tablespoons for West Virginia subjects were 0.46, 0.37, 0.60, and 0.32, all significantly different from unity. Two other coefficients were actually negative, but because of the small numbers involved, they carried little weight. It should be noted that either of these trends could exist simultaneously with the finding of consistent overestimation on a group or mean basis. Thus, if West Virginia subjects tended to underestimate portion size as actual size increased, they tended to overestimate as portion size decreased. This same condition (reversed) was also true of the New Jersey subjects.

For foods measured in ounces, there was a consistent tendency to underestimate size when actual size increased for subjects at both stations. With the exception of soup in the New Jersey data, the regression coefficients of 0.74, 0.76, and 0.77 tended to be less than unity, but none significantly so. The one coefficient from the West Virginia data, 0.81, also reflected this trend, this value being significantly different from unity because of the larger number of observations. Again on a group basis, the mean of the estimated portions was higher than the mean of the actual portions for both stations.

Both stations also offered data for foods measured in cubic inches. Three of the four regression coefficients were considerably less than unity, the values being 0.60, 0.49, 0.51, and 1.31. Since this unit did not tend to be as precise as some others in estimating food portions, it was felt that beyond pointing out these results, further emphasis on cubic inches was not warranted.

Effect of Failure to Report All Foods Eaten — Omissions

The data from Maine, Massachusetts, and New Jersey do not offer us opportunity to study the effect of failure to report all foods eaten. For the Maine and Massachusetts subjects, because of the method of study employed, no omissions could be made. For the New Jersey subjects there was no possible means of checking on items omitted from the food records; the study represented only a means of checking the quantitative estimations of certain items reported.

The New York, Rhode Island, and West Virginia studies were set up in such a way that a check was possible on the food items actually omitted. There was a considerable number of omissions for all three types of subjects; however, there were more omissions by the junior high students and the West Virginia college students than for the Rhode Island college home economics students, a special group. The greatest omissions appeared to be in such food types as "puddings," sauces and gravies, beverages, bread and rolls, butter and fruits. The smallest number of omissions appeared in meats, eggs, cookies, pies and cakes.

In considering the effect of omissions, it should be noted that the mean actual serving may or may not change while the mean reported serving will always decrease when zero is substituted for the omission. Thus, omissions tend to decrease the size of the estimates, thereby presenting a potential bias, which was found in these studies to be neither consistent nor predictable in types of subjects, food types, or units.

Effect of Estimation of Food Portions on Nutritive Value

One exceedingly important practical question not yet answered in the studies reported here is: What influence on apparent nutritive intake do these differences in portion estimations have? This question is being investigated. For some food types large differences between reported and actual means would have little effect on nutritive intake; for others, relatively small errors in estimation would have considerable effect on the nutritive value of the diet. Meredith *et al.* (27) found that though children showed considerable lack of agreement by comparisons of items recorded by weighing and the child's estimation by recall, the differences were still relatively small according to calculated analyses based on the two methods.

From the findings reported here several recommendations might be made. It would appear that errors in estimation of size of food portions are probably the largest source of error in diet record-keeping. The indications are that for the study of nutrient intake on an individual basis, weighed or measured food records are to be desired. Certain individuals trained in foods work or accustomed to handling food may be expected to estimate food portions more accurately than other individuals. If weighed or measured records are not possible, it appears to be well for subjects to know that every means

is being used to check upon the accuracy of their estimations and recordings. The evidence is that where subjects know that they are being checked, much more accurate estimations are made. However, some food items are not estimated well by even the most trained and conscientious subjects.

On a group basis, errors of estimation of portion size for most food types are probably within 20 per cent except for children's recall. For many food types there were remarkably good agreements between estimated and actual mean portion sizes for most of the types of subjects studied. Meredith *et al* (27) reported that for their school children, on a group basis, errors of estimation cancelled out in such a way that they did not seriously interfere with obtaining reasonable estimations of the average intake of a group. However, errors might be of a significant nature if one were primarily interested in nutrient intake on an individual basis. Chamberlain and Pike (26), working with freshmen University women, found that the average nutritive value of the diet eaten by the group was in close agreement when obtained by weighing or by estimated records kept by the individuals; however, the intakes of individuals showed considerable variation.

Since in the collection of unweighed diet records, it seems apparent that there will be errors in estimation of food portions, every effort should be made to accumulate data on sizes of portions commonly served to the type of subjects under study.

More studies are necessary on the effect that the subject's ability to estimate food portions has on the estimated nutritive value of diet conducted under conditions comparable to those of actual diet record collection. In the present studies in most instances conditions were sufficiently different that findings may not be applied directly to the interpretation of the dietary data collected.

Summary and Conclusions

Investigations were undertaken to study the ability of several types of subjects to report accurately the size of food portions consumed, without the subjects' being aware that they were being checked. In most instances it was not possible to simulate the original conditions under which diet records were kept; hence, findings are not directly applicable to dietary studies reported by this group of investigators.

From results of these studies it would appear that errors in estimation of portion sizes are probably the largest source of error in diet record-keeping.

Of the types of subjects studied, college Home Economics students most accurately estimated size of food portions; other college students and junior high school pupils were least accurate in their estimations; homemakers and male industrial workers were in an intermediate position.

Of the types of foods studied, those that could be reported on an item or count basis or readily measured in terms of cups or tablespoons, such as soups, sugar, beverages, bread and rolls, cookies, and eggs, were most ac-

curately estimated. Such food types as "puddings," sauces and gravies, and fruit were least accurately reported. Meats, vegetables and salad, and "casseroles" were in intermediate positions.

It was noticeable that subjects had a tendency to overestimate food servings, a bias partially compensated by their failure to report some of the foods eaten or amount left on plates. However, this compensating factor of omission was neither consistent from subject type to subject type nor from food type to food type.

Indications are that for the study of nutrient intake on an individual basis, weighed or measured food records are desirable. Certain individuals trained in foods work or accustomed to handling food might be expected to estimate food portions more accurately than other individuals. If weighed or measured records are not possible, it appears to be well for subjects to know that every means is being used to check the accuracy of their estimations. According to the evidence, it seems that subjects who know they are being checked make much more accurate estimations; however, some food items are not well estimated even by the better trained and conscientious subjects.

On a group basis, errors of estimation of portion sizes for most food types are probably within 20 per cent except for children's recall. For many food types there were remarkably good agreements between estimated and actual mean portion sizes for most of the types of subjects studied.

No evidence is presented concerning the effect that errors of estimation and omission in reporting food portion sizes have on the estimated nutritive value of the diet.

There is need for further study of subject's ability to estimate food portion sizes under circumstances completely comparable with those existing during the conduct of dietary studies.

INFLUENCES OF DIETARY INTERPRETATIONS ON THE CALCULATED NUTRITIVE VALUE OF THE DIET

Betty F. Steele and Ruth E. Tucker

During the statistical evaluation of different methods of assessing dietary intake, the question was raised regarding how much effect the interpretation of the dietary calculator had upon the estimated nutritive value of the diet. The study reported here was undertaken to answer this question.

Methods

Three individuals at the Rhode Island Experiment Station calculated the dietary intake of 10 nutrients from the same 20 seven-day diet records. Three different calculators at the Cornell University Agricultural Experiment Station independently calculated 80 seven-day records. The individual interpreters varied in their educational training and in the length of time they had spent doing dietary calculations. All, however, had some previous training in dietary interpretations. The nutritive values calculated by the individual interpreters were compared statistically by the analysis of variance method (49).

Results

There were no significant differences, as judged by F values, between the nutritive values calculated from the 20 records by the three interpreters from Rhode Island. In the case of the New York interpreters, however, significant differences for the calculations for niacin and iron intake were found (probability equal to or less than one per cent). Inspection of the individual items that contributed to the total calculated values revealed that variations in the estimations of the amounts of bread and meat consumed by the subjects accounted for most of the differences noted.

Summary

From the foregoing results it would seem that individuals with some training in dietary calculations can interpret seven-day food records into nutritive values that do not vary significantly from those calculated by other such individuals. Niacin and iron values may be exceptions to this. The estimation of the amounts of meat and bread ingested exerts a great influence on the calculated values for these nutrients.

COMPARISON OF DETERMINED AND CALCULATED AMOUNTS OF EIGHT NUTRIENTS IN ONE DAY'S FOOD INTAKE OF TWENTY-ONE SUBJECTS

Anne W. Wertz, Mary E. Lojkin, Ellen H. Morse, Gladys C. Hagan, and Priscilla S. Van Horn

Many reports on the comparison of analyzed and calculated values for food nutrients have appeared in the literature. The results described in these reports have been quite variable. Reasons for the variability in both the laboratory analysis of foods and in the tables of food composition have been discussed by Thomas *et al.* (42). These authors pointed out that some of the causes of discrepancies in agreement are the analytical methods, the locality at which the food is grown, the maturity of the food, the time of year, and the food value tables.

In the nutritional status study in the Northeast Region it seemed pertinent to determine the reliability of the food value tables in the calculation of the nutrients in the dietaries of the subjects. A study, therefore, was carried out by the Nutrition Research Staff at the University of Massachusetts. The results of the comparison of the determined values for protein, fat, calcium, phosphorus, thiamine, riboflavin, niacin, and ascorbic acid in 21 diets with the values calculated from the U.S. Public Health Service Table (46) supplemented with the tables of Bowes and Church (47) are reported here.

Methods

Collection and Preparation of Food Samples

All food eaten for one day by each subject was weighed, and duplicate amounts placed in a refrigerated glass jar containing 1 N-H_2SO_4. This composite food sample was puréed in a Waring Blendor, the total sample and washings weighed, mixed again, and suitable aliquots weighed in triplicate for the analyses of protein, fat, calcium, phosphorus, thiamine, riboflavin, and niacin. For ascorbic acid analyses, weighed aliquots of all the foods eaten except meat and cereals were placed in a refrigerated glass jar containing 16 per cent metaphosphoric acid. This food sample was puréed in a Waring Blendor, the total sample and washings weighed, remixed, and aliquots taken for ascorbic acid determination.

Analytical Methods

Thiamine was determined by the thiochrome method, including enzyme treatment and the purification procedure; nicotinic acid and riboflavin were determined by the microbiological assays as outlined by the Association of

Vitamin Chemists (55). The indophenolxylene extraction method of Robinson and Stotz (56) was followed for the determination of reduced ascorbic acid. Total ascorbic acid was determined by treatment of the sample with H_2S, as described by Bessey (57), and subsequent extraction with xylene. Calcium was determined by the potassium permanganate method of the Association of Official Agricultural Chemists (58). A slight modification of Tisdall's (59) method was used for the analysis of phosphorus. Nitrogen was determined by the Kjeldahl-Gunning-Arnold method as described by the Association of Official Agricultural Chemists (58). The factor, 6.25, was employed to convert the nitrogen value to the corresponding amount of protein. Fat was determined by the extraction of the wet sample with ethyl ether, and subsequent extraction with a mixture of ethyl ether and alcohol as recommended by Saxon (60). The combined extracts were dried and weighed.

Results and Discussion

A comparison of the analyzed values with the calculated values for eight nutrients is presented in Table 20. The calculated values for protein, calcium, phosphorus, thiamine, and niacin do not differ significantly from the determined values. However, it can be seen that considerable differences existed between the analyzed and calculated values for thiamine and niacin for the individual samples because only about one-half of the calculated values fell within ± 15 per cent of the analyzed values for these nutrients. The calculated values for fat were significantly higher than the analyzed values with 11 of the 21 values falling within ± 15 per cent of the analyzed

TABLE 20

Comparison of Analyzed and Calculated Values for Food Intake of Twenty-One Subjects for One Day

Nutrient	*Analyzed Value*	*Calculated Value*	*Mean Difference ± S.E.M.D.*	*Number of Cases of Calculated Values*		
				Higher than Analyzed	*Lower than Analyzed*	*Within ± 15 Per Cent of Analyzed*
Protein, gm.	62.3	59.8	2.57 ± 1.61	6	14	14
Fat, gm.	68.8	75.7	6.95* ± 1.55	15	4	11
Calcium, gm.	0.872	0.871	0.001 ± 0.024	11	7	15
Phosphorus, gm.	1.16	1.12	0.04 ± 0.04	10	10	15
Thiamine, mg.	1.01	0.93	0.08 ± 0.05	7	12	10
Riboflavin, mg.	2.14	1.60	0.53* ± 0.11	3	17	5
Niacin, mg.	10.0	10.1	0.07 ± 1.94	11	10	10
Ascorbic acid						
Reduced, mg.	70.2	84.3	14.1* ± 5.84	14	5	6
Total, mg.	87.6	84.3	3.25 ± 7.05	9	11	4

* Difference significant (test for significant differences was made by applying the "*t*" test for comparison of individuals as described by Snedecor (49). The difference is significant at the 5 per cent level when *M.D./S.E.M.D.* > 2.086).

values. The estimated amounts of riboflavin were consistently and significantly lower than the analyzed values; only five of the calculated values agreed within ± 15 per cent of the analyzed values. The calculated values for ascorbic acid were significantly higher than the analyzed values. Although the mean difference between the calculated value for ascorbic acid and the analyzed value for total ascorbic acid was not significant, the differences for the individual samples were great. This particular agreement in the mean value is probably due to chance.

Meyer *et al.* (61) found no significant differences between the analyzed and calculated values for protein, calcium, and fat, but a significantly higher analyzed value for riboflavin and significantly lower analyzed values for ascorbic acid and thiamine. Kaucher *et al.* (36) reported that the calculated values for protein, riboflavin, and niacin closely approximated the analyzed values, but that the calculated value for fat was 14 per cent and for thiamine 27 per cent higher than the analyzed values. McCay and coworkers (35) stated that calculated values gave a fair approximation of determined nutrients except for calcium, which was too low, and for fat, which was too high. Toscani (40) found that calculated values for protein, calcium, and phosphorus showed good agreement with analyzed values. Patterson and McHenry (29) reported that analyzed values for protein agreed well with calculated values, but that the analyzed value for fat was too low. Bransby *et al.* (41) found that average calculated values for protein, fat, and calcium agreed well enough with analyzed values for practical purposes. Shetlar *et al.* (62) found the calculated value for thiamine to be about 14 per cent higher than the analyzed value. Young and McHenry (30) reported that the analyzed value for ascorbic acid was significantly lower than the calculated value. Semmons and McHenry (31) stated that calculated values for calcium were probably about 15 per cent higher than the actual value.

A limited amount of published data indicates that the time or season of the year affects the agreement of calculated values with analyzed values for food nutrients. Steinkamp *et al.* (63) found that in the spring the determined values for thiamine were consistently higher than the calculated values, whereas, in the fall, the determined values agreed well with the calculated values. In the fall (no spring values) the determined riboflavin values exceeded the computed values. The analyzed values for niacin and ascorbic acid were lower than the estimated values in both spring and fall. Thomas *et al.* (42) reported no significant differences between the calculated and analyzed values for calcium, phosphorus, protein, and ascorbic acid in either the spring or fall. They found that the analyzed value for thiamine was significantly lower than the calculated and that the analyzed value for riboflavin was significantly higher than the computed value. The differences between the analyzed and calculated values for fat were highly significant, but the direction varied with the season and, for the total analyses made, there were no significant differences. Determined values for niacin were significantly higher in the fall than the estimated values. However,

there were no significant differences in the spring or when the values were considered for the total number of cases.

Summary

From the results of the present study and the published work, it appears that a fairly good estimation of the protein, calcium, phosphorus, and niacin in dietaries may be made by calculation from food value tables. Estimation of thiamine may be too high, although the evidence is conflicting. Calculated values for fat and ascorbic acid would probably be significantly higher than the actual intake, but calculated values for riboflavin would undoubtedly be significantly less than the actual amount eaten. Because of the large differences between calculated and determined values for individual samples and analyses, it would be necessary to have several diet records from the same individual to obtain a valid estimation of that individual's nutrient intake.

SUGGESTED PROCEDURES FOR DIETARY STUDIES

Study of the Intake of the Individual

When the objective of the dietary study is an estimation of the nutritive intake of an individual, especially for correlation with nutritional status findings, it is apparent from studies reported here that every effort should be made to obtain precise information: the more precise the method, the better. Actually a diet record recorded in terms of weights is desirable whenever possible because of the inaccuracies involved in the subjects' attempts to estimate intake. Failing a weighed record, measurement of intake in household units would seem the next most desirable procedure. Ideally, aliquots of the dietary intake should be subjected to laboratory analysis.

The number of days for which the intake would need to be studied depends upon the degree of precision that is desired. An instrument is presented for estimating the number of days necessary to achieve any given precision. It does not appear to make any difference on what day of the week the record-keeping is initiated, but the days selected should run consecutively from the starting day for the length of time estimated to be necessary to achieve the desired degree of precision.

If an unweighed dietary record is used to study the intake of an individual, it is probably a wise investment of time for a nutritionist to check the records individually with the subjects for size of servings, foods in combination dishes, possible omissions of between-meal foods or such items as butter and salad dressing (64).

Though data are not yet available to compare the relative accuracy of the record with the dietary history method, it would be advisable to use a record kept a sufficiently long time, unless the individual had been alerted to be aware of his food intake previous to the taking of the dietary history. It is generally the impression that except under unusual circumstances most children and adults are not unduly aware of their food intake. Groups who are particularly food conscious such as home economics students or those who eat in mass feeding units where considerable regularity in food pattern is involved, as in college dormitories, may be able to give dietary histories that more closely resemble their dietary records. Dietary histories are time-consuming (requiring one to one-and-one-half hours each to elicit) and costly in terms of trained personnel required. If the dietary history method is to be used, it is suggested that the subjects be prepared for the procedure, perhaps by previous record-keeping as a basis for the interview. For a long-time view of the diet, it may be the only possible procedure. Preference might be given to obtaining several records, of sufficient length, kept at different times of the year. Many individuals, however, do not respond to the seven-day record methods. Subjects who have so little interest in nutrition that they are unwilling to keep dietary records may be those whose

nutritional status is particularly important to study. Thus, in the study of industrial workers in New Jersey, of 55 subjects willing to be interviewed, only nine cooperated by keeping seven-day records. Of all subjects interviewed at New Jersey, only half returned seven-day records. This half had higher educational levels (an average of two-thirds of a year more schooling), slightly higher incomes, and, most important to the bias of the data, slightly higher blood ascorbic acid levels.

Preliminary or pilot studies should be made to determine whether or not there may be seasonal variation in the dietary intake, and, consequently, necessity for seasonal repetition of studies. Indications at present are that the seasonal effect is minimal for individuals from the middle economic range living in urban communities.

Study of the Intake of a Group

For characterizing a group by its mean intake, a one-day record or 24-hour recall would appear to be the most efficient method of study. The number of subjects needed to predict the intake within a given precision may be estimated. On the average, the day of the week appears to be immaterial; however, for any particular group, the "which day" effect should be investigated before any survey is undertaken.

Since in the present investigations, the seven-day record and 24-hour recall appeared to give similar results on a group basis, expediency would surely suggest the shorter 24-hour recall. If, in terms of convenience, such as lack of interviewers, a one-day record may be easier to obtain, the evidence is that it may be substituted. However, if there is reason to believe that subjects may change food intake for one day when asked to keep one-day records, it would be more accurate to take 24-hour recall. There is no evidence in the present investigations nor in those of Trulson (14) that the first day of record-keeping is essentially different from succeeding days. This effect may be more common among those educated in the essentials of an adequate diet than among the population as a whole.

If the interviewers are trained nutritionists with some experience in interviewing, there need not be concern over the influence that different interviewers may have on group values for nutrient intake.

Results of studies for this project also indicate that within the range of the type of individuals calculating the dietary records under investigation, the differences in interpretation of the dietary records by the calculators are not a significant factor in the estimation of the average nutritive intake of the group.

Errors in the estimation and omission of food portion sizes by the subjects are probably the source of greatest variation in dietary record-keeping.

It would seem desirable to calculate dietary records obtained for groups rather than to check by means of food usage or comparison with a food pattern. Arguments against the calculation of dietary records for nutrients

have, in general, been twofold: (1) the time and special training required and (2) the understandable reluctance of many investigators to assign quantitative values to the records collected. The first argument is now at least partially negated by faster and more simplified ways in which to calculate nutrients (Babcock, 1950) (48), which may be used by relatively inexperienced personnel. On the basis of the second argument, food checks are often used rather than nutrient calculation. If the diet evaluation stopped here, the present investigators should be the first to agree. However, almost invariably, either the investigator himself or the persons using his results eventually interpret the food checks in terms of adequacy of nutrient intake. In many cases these interpretations are more erroneous than the quantitative assumptions in the calculation of the original records on a nutrient basis, since it is almost impossible to find an adequate means of checking dietary records by foods because of the many food patterns by which an adequate diet may be achieved (Young and Musgrave, 1951) (65).

In conclusion, for studies of the average dietary intake of a group, the simplest possible techniques seem justified.

Pilot Studies

The present studies point to the desirability of pilot studies before undertaking mass dietary studies to determine the simplest methods to achieve the objective under consideration. Such pilot studies may well save time, money, and personnel as well as lend greater confidence in the findings of the mass investigation.

STATISTICAL APPENDIX

A. Bias

The test for bias given in the text does not include the possibility of a line with unit slope passing through a point denoted by the means of each method when these means are unequal. Bias would be present in this case. From this, it might be argued that any line fitted to these trends should pass through the origin, then any departure of the slope from unity could be ascribed to bias. Such a fit would not have meaning because these estimates tend to maintain their relative bias in the low values as well as in the high.

That this estimate of the true relationship between history and seven-day record is not itself unbiased has been pointed out by Winsor (66). Investigation of methods to correct for this bias was not followed here because it has sufficient value for our purpose as a preliminary test.

The reader may ask why we chose to compute the specific regression of seven-day record on history instead of history on seven-day record; likewise, why not seven-day record on 24-hour recall and four-day record on history? From a theoretical point of view in sampling from a normal bivariate population in order to estimate the true relation between two variables, it makes no difference which way the regression is computed. However, if the variation in one variable is greater than the variation in a second, a least squares fit does not always follow the trend indicated on a scatter diagram. To follow this trend as closely as possible, the variable with the greater variation was denoted as the "*X*" or independent variable as often as possible.

B. Heterogeneity of Mean Differences

This is a straightforward analysis of variance which partitions the variation into two sources, between mean differences and within differences.

A numerical example is given below:

Heterogeneity Test of Mean Differences Between History and Seven-Day Record

Analysis of Variance on Vitamin A, 100's of I.U.

Source	*d.f.*	*S.S.*	*M.S.*	*F*
Between Mean Differences	2	41,265	20,632	5.21**
Within Mean Differences	144	543,387	3,957	

The assumption most likely violated in this test is in regard to pooling the within sums of squares. The effect of this is not believed to impair the validity of the conclusion drawn from this test.

C. Correlation Necessary for Prediction

First, it is necessary to find the predicted value ($\hat{Y}$) from the relationship between Y and X, given that the predicting variable (X) has a value of 1.50 grams. From either the computed regression or from figure 1, the value of $\hat{Y}$ was found to be 1.06 grams. Then 20 per cent of this value is 0.212 grams.

Next we need to set confidence limits on the estimated value of Y such that a deviation from $\hat{Y}$ of more than 20 per cent in either direction would be considered significant.

If we let D = a significant deviation at the 5 per cent level, then $D = 0.212$.

To compute one-half of the confidence interval,

$$D = t_{05} s.e.(\hat{Y}) \qquad (1)$$

In Snedecor's (49) notation,

$$s.e.\ (\hat{Y}) = s_{y.x}\sqrt{1 + 1/N + (X - \bar{X})^2/Sx^2}, \qquad (2)$$

where the relation of $s_{y.x}$ to the correlation coefficient is given by

$$s_{y.x} = \sqrt{(1 - r^2)Sy^2/(N - 2)}. \qquad (3)$$

Substituting for $s_{y.x}$ in equation (2), for $s.e.\ (\hat{Y})$ in (1), and solving for $1 - r^2$, we obtain,

$$1 - r^2 = (N - 2)D^2/\{t_{05}^2 Sy^2[1 + 1/N + (X - \bar{X})^2/Sx^2]\}.$$

From the data for Massachusetts, we have the following values:

$$\begin{aligned} D &= .212 \\ t_{05} &= 2.01 \\ N &= 47 \\ Sy^2 &= 3.9370 \\ Sx^2 &= 9.7768 \\ X &= 1.50 \\ \bar{X} &= 1.21 \end{aligned}$$

From these, we compute

$$1 - r^2 = .1248$$

or

$$r = .9355$$

D. Heterogeneity of Regression Coefficients

This method which can be found in Goulden (67) has been extended to include lots of unequal sizes. A sample calculation is given here for illustration.

Heterogeneity Test of Regression Coefficients of Regression of Seven-day Record on History

Analysis of Variance on Phosphorus, gms.

Source	*d.f.*	*S.S.*	*M.S.*	*F*
Σ Regressions	5	22.5460		
Average Regression	1	21.4585		
Between Reg.-Coefficients	4	1.0875	.2719	1.31 NS
Σ Deviations from Reg.	466	96.3072	.2067	

Intermediate Values

$\Sigma Sxy = 49.6212$

$\Sigma Sx^2 = 114.7454$

Steps: 1. Notation

a. X = History, Y = Seven-day Record

b. Σ indicates the values are summed over the stations presenting data for this comparison

c. *S.S.* = Sum of squares, *M.S.* = Mean square, *d.f.* = Degrees of freedom

2. Compute the intermediate values, and Σ Regression sums of squares and Σ Deviations from regressions from the individual regression analyses.

3. Compute Average Regression as $(\Sigma Sxy)^2/\Sigma Sx^2$.

4. Subtract Average Regresssion degrees of freedom and sum of squares respectively from Σ Regressions to obtain between regression coefficients as a source of variation.

5. The usual F test is made on the mean squares for the last two items.

Assumptions: It is assumed in pooling the deviations from regressions that their mean squares are homogeneous. Cochran (68) states that failure for this assumption to be met, as here, has the least effect on the probability levels for the F ratio but results rather in a less sensitive test. For our purpose here, this test is sufficient.

E. Consecutive Days are Independent

Detailed examination of 18 twenty-eight-day records and 13 fourteen-day records in addition to the seven-day records failed to give evidence of any serial correlation as defined and tabulated by Anderson (69) in consecutive

days. There was no evidence of autocorrelation as described by Orcutt (70) in either the days themselves or the residuals. A third check consisted of computing the regression of $\sigma^2(1 - \rho)/r$ estimated from consecutive days on σ^2/r estimated from random days, where ρ is the correlation between every pair of residuals as described by Cochran (71). For $\rho \neq 0$ the regression coefficient should deviate noticeably from unity; because it did not, the hypothesis of zero correlation was retained. Assuming normality, it was concluded with the finding of zero correlation that consecutive days may be considered as independent.

F. Variance Components

The model used for the analyses of variance is given by

$$Y_{jk} = m + D_j + I_k + e_{jk}, \quad j = 1 - d, \quad k = 1 - i,$$

where Y_{jk} = observation on the kth individual for the jth day,
D = day effect, $N(O, \sigma_D^2)$,
I = individual effect, $N(O, \sigma_I^2)$, and
e = residual, $N(O, \sigma^2)$.

The problem was to minimize the variance of the grand mean, i.e., $Y..$, subject to a cost or convenience function approximated from consideration of computing time and subjects' cooperation. This expression is written as

$$V(Y..) = \sigma^2/id + \sigma_D^2/d + \sigma_I^2/i + \lambda(C),$$

where C = cost per individual relative to an additional day and evaluated as $C \leqq 1.0$.

Solution of the equations resulting from $\partial V(Y..)/\partial i = 0$ and $\partial V(Y..)/\partial d = 0$ gave the result,

$$d = (\sigma/\sigma_I)\sqrt{C} \leqq 1.13,$$

since σ_D^2 was estimated to be zero.

G. Development of the Measure of Precision for a Number of Days

The 95 per cent confidence limits for the mean of d days for an individual are given by

$$Y_{.k} \pm t_{05}\sqrt{\sigma^2/d},$$

where σ^2 is the average variance of an individual's intake on one day. Therefore, the 95 per cent confidence interval divided by the NRC Daily Recommended Allowance offers an index of precision given by

$$P = C.I./\text{NRC} = 2t_{05}\sqrt{\sigma^2/d}/\text{NRC}.$$

Solving for $\sqrt{d}$, we have

$$\sqrt{d} = 2t_{05}\sigma/P\ \text{NRC}.$$

Since the ratio, σ/NRC, was found to be constant by sex for all population types, this relationship was valid for an individual (on the average) and can be assumed to apply to individuals from population types similar to these.

Confidence limits on d are available directly from the consideration that s^2/σ^2 is distributed as Chi-square/$d.f.$ For example, the upper and lower 95 per cent confidence limits on an estimate of fourteen days for an individual male are 17 and 11 respectively.

H. Development of Precision for Number of Subjects

Similar to the procedure above, the 95 percent confidence limits for the means of a group of i individuals for one day are given by

$$\bar{Y}_{j\cdot} \pm t_{05}\sqrt{(\sigma^2 + \sigma_I^2)/i}$$

Solving for $\sqrt{i}$, we have

$$\sqrt{i} = 2t_{05}\sqrt{\sigma^2 + \sigma_I^2)}/P\ \text{NRC},$$

where again the ratio, $\sqrt{(\sigma^2 + \sigma_I^2)}$/NRC, was constant by sex for all population types. For illustration, the approximate 95 per cent confidence limits on an estimate of sixty persons in a group are 74 and 46 respectively.

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